HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

# 413A

Prefix 139

# DC NULL VOLTMETER

413A

## CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

HP FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

OPERATING AND SERVICE MANUAL

# MODEL 413A/AR

SERIALS PREFIXED: 139

# DC NULL VOLTMETER



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### VOLTMETER

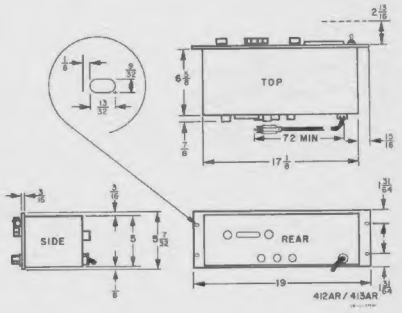
| | |
|---|---|
| Ranges: | Positive and negative voltages from 1 mv to 1000 volts end scale in 13 zero-center ranges |
| Accuracy: | ±2% of end scale |
| Limits of Zero Control: | Approximately ± end scale on any range |
| Input Resistance: | 10 megohms on 1, 3, and 10 millivolt ranges<br>30 megohms on 30 mv range<br>100 megohms on 100 mv range<br>200 megohms on 300 mv range and above |
| AC Rejection: | A voltage at power line or twice power line frequency 40 db greater than end scale affects reading less than 1%. Peak voltage must not exceed 1500 volts. |

### AMPLIFIER

| | |
|---|---|
| Gain: | 0.001 to 1000 in 13 steps |
| Gain Accuracy: | ±1-1/2% |
| Linearity: | ±0.2% |
| Noise: | Less than 0.1% (rms) of end scale on any range |
| Output: | 1 volt for end scale deflection, same polarity as input signal. End scale corresponds to 1.0 on upper scale. Maximum load current is 1 milliampere. |
| Output Impedance: | Less than 2 ohms at dc |
| AC Rejection: | Approximately 3 db at 1 cps, 80 db at 50 and 60 cps |

### GENERAL

| | |
|---|---|
| Input Terminals: | Binding post |
| Input Isolation: | Greater than 100 megohms shunted by 0.1 μf to case (power line ground) |
| Common Signal Rejection: | May be operated with up to 500 volts dc or 130 volts ac above ground |
| Power: | 115 or 230 volts ±10%, 50 to 60 cps, approximately 35 watts |
| Dimensions: | Cabinet Mount: 11-1/2 inches high, 7-1/2 inches wide, 10 inches deep |
| | Rack Mount: |




| | |
|---|---|
| Weight: | Cabinet Mount: Net 12 lbs, shipping 17 lbs |


Figure 1-1. Model 413A DC Null Voltmeter

# SECTION I
# GENERAL INFORMATION

## 1-1. INTRODUCTION.

1-2. SCOPE. This manual supplies operation and maintenance information for the ® Model 413A DC Null Voltmeter. A performance check that may be used for verifying specifications during incoming inspection is given in paragraph 5-40.

1-3. INSTRUMENT IDENTIFICATION. Hewlett-Packard Company uses a two-section eight-digit serial number (e.g. 000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, yellow change sheets have been supplied with the manual which define differences between your instrument and the model described in this manual. If these change sheets are missing, your Hewlett-Packard sales representative can supply you with this information.

## 1-4. DESCRIPTION.

1-5. GENERAL. The Model 413A DC Null Voltmeter is a zero-center dc voltmeter with end scale ranges from 1 mv to 1000 volts in a 1-3-10 sequence. Input impedance varies from 10 megohms to 200 megohms depending on the setting of the RANGE (VOLTS) switch. The input terminals are isolated from the cabinet and ground permitting operation from references up to 500 volts dc or 130 volts ac from ground potential.

1-6. INDICATORS. In addition to the conventional meter, which has both a normal (±10% of full scale) and expanded (± full scale) range of zero adjustment, the Model 413A has amplifier output connectors which provide an output voltage proportional to meter deflection. This feature makes it possible to use the Model 413A as a dc amplifier for use with thermocouples, etc., or to use it in conjunction with a recorder to obtain permanent records without the need for constant monitoring.

1-7. USES. The Model 413A may be used for any application that calls for a dc null voltmeter. High input impedance of the instrument makes it especially valuable for resistance bridge measurements. The high voltage gain and the exceedingly low drift and noise make the Model 413A an ideal instrument for many control applications, particularly where the system must be left unattended for long periods of time.

## 1-8. THREE-CONDUCTOR POWER CABLE.

1-9. For the protection of operating personnel, the National Electrical Manufacturers' Association (NEMA), recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

## 1-10. CALIBRATION ACCURACY.

1-11. The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected, and found to meet its published specifications when it was shipped from the factory.

1-12. It further certifies that its calibration measurements are traceable to the National Bureau of Standards to the extent allowed by the Bureau's certification facility.

1-13. Adjustments should not be attempted unless malfunction has been definitely established by following the performance verification check in paragraph 5-40 of this manual.

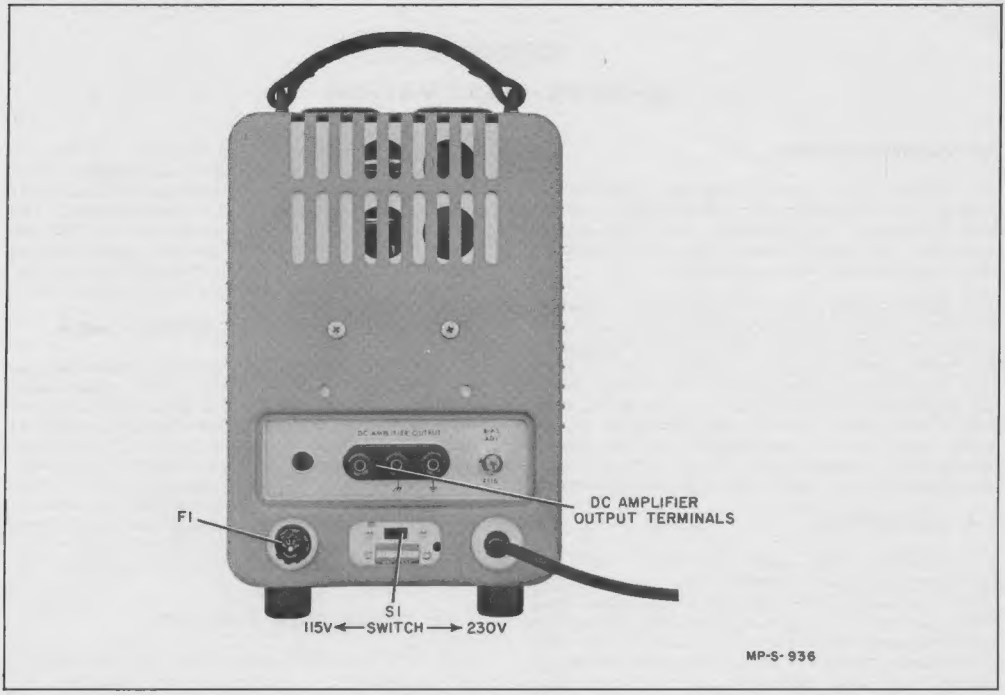



Figure 2-1. 230-Volt Operation


Figure 2-2. Rack Mount Unit

# SECTION II
# PREPARATION FOR USE

## 2-1. INCOMING INSPECTION.

2-2. MECHANICAL INSPECTION. Care is taken in packing Hewlett-Packard instruments to assure undamaged delivery. Despite these precautions, however, damage in shipment will sometimes occur. Upon receipt of your 413A, check the contents against the packing list and inspect the instrument for any obvious damage received in transit. If damage is evident, file claim with the carrier. To facilitate reshipment, keep the packing material until an operational check has been made (see paragraph 2-3). Refer to the warranty sheet in this manual for additional information.

2-3. OPERATIONAL CHECK. Paragraph 5-40 includes an in-cabinet check for verifying proper instrument operation as given in published specifications. If the Model 413A is to be operated from a 230-volt source refer to paragraph 2-8.

## 2-4. RESHIPMENT.

2-5. If, after incoming inspection, damage is evident, repack the instrument in its original shipping container taking care to replace all pads in their original positions. If the packing material was discarded, contact your nearest Hewlett-Packard sales office for information and/or packaging material. If this is not possible, the Model 413A should be packed in a strong exterior container and surrounded by 3 to 4 inches of cushioning material designed specifically for package cushioning.

## 2-6. INSTALLATION.

2-7. No special installation procedures are required for the Model 413A cabinet model. The Model 413AR rack mount (figure 2-2) mounts in a standard 19-inch rack. Amplifier output connectors are provided on both front and rear of the Model 413AR rack unit.

## 2-8. 230-VOLT OPERATION.

2-9. If 230-volt operation is desired, a screwdriver-operated switch (see figure 2-1) is provided on the rear of the instrument. A fuse of different rating should be used. See Table of Replaceable Parts in section VI.

## 2-10. ENVIRONMENTAL LIMITS.

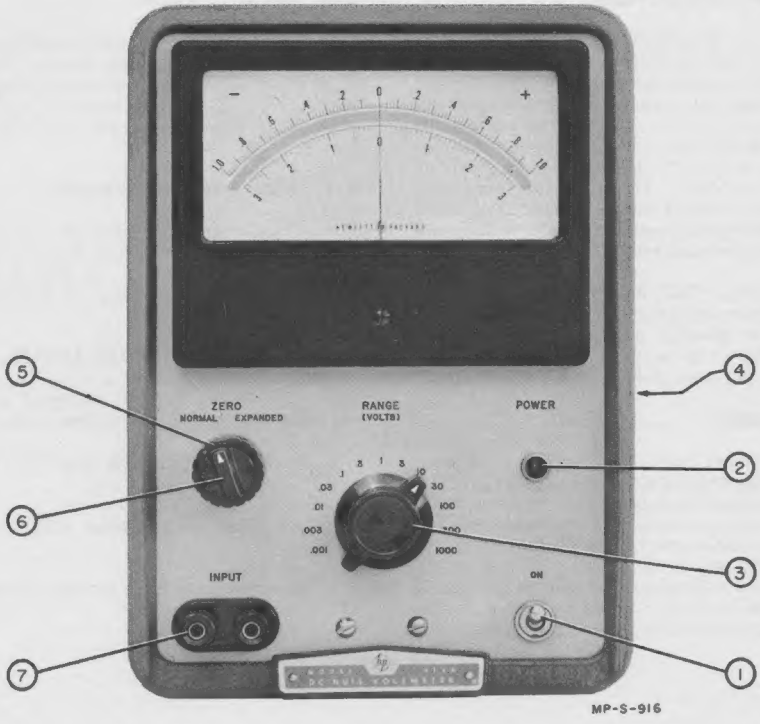
2-11. The Model 413A is designed to operate within the following environmental conditions.

a. Storage temperature: $+167^{\circ}F$ ($75^{\circ}C$) to $-40^{\circ}F$ ($-40^{\circ}C$).

b. Operating temperature: $130^{\circ}F$ ($55^{\circ}C$) to $32^{\circ}F$ ($0^{\circ}C$).

c. Radio interference: meets the requirements of MIL-I-169104.

d. Altitude: 0 to 25,000 feet.




1. Power switch. Turns instrument ON.
2. Pilot Light. Lights when instrument is ON.
3. RANGE (VOLTS) switch. For selecting voltage range desired.
4. Amplifier Output terminals (rear of instrument, not shown). Provides an output voltage proportional to meter deflection.
5. ZERO control. Used to adjust electrical zero setting of meter.
6. NORMAL-EXPANDED switch. Provides a choice of EXPANDED (± end scale) or a NORMAL (± 10% end scale) range of zero adjustment.
7. INPUT connectors. Apply voltage to be measured here (413A input is fully floating).

Figure 3-1. Operating Controls

# SECTION III
# OPERATING INSTRUCTIONS

## 3-1. INTRODUCTION.

3-2. GENERAL. This section contains information on the function and use of all controls on the Model 413A DC Null Voltmeter. If more theoretical information is desired, refer to section IV, Principles of Operation.

3-3. LOW-LEVEL ELECTRICAL PHENOMENA. Stray low-level electrical phenomena are present, in one form or another, in nearly all electrical circuits. The 413A does not distinguish between stray and signal voltages; it measures net voltage. Thus, when using the lower voltage ranges, consider the possibility of low-level electrical phenomena. Thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (dielectric absorption), battery action of two terminals mounted on an imperfect insulator (galvanic action) all can produce voltages within the range of the 413A.

3-4. Whenever possible, use copper wire leads and maintain the points of connection at the same temperature, preferably ambient temperature. With the leads so connected, any voltage indicated by the 413A is developed within the circuit under test.

## 3-5. CONTROLS.

3-6. Figure 3-1 shows all operating controls and gives a short description of their use. Numbers in figure 3-1 are given to relate the text in figure 3-1 to the photograph, and do not necessarily indicate operational procedure (see paragraph 3-7). More detailed information related to these controls is listed below:

a. RANGE (VOLTS) switch. The RANGE (VOLTS) switch adjusts the input circuit so that any voltage between .001 and 1000 volts may produce end scale deflection on the meter. The last position of the RANGE (VOLTS) switch is used to adjust the cathode follower bias (see paragraph 5-34).

b. INPUT terminals. The voltage to be measured should be connected to these terminals. Polarity is not important insofar as 413A operation is concerned. However, to prevent ac loading of the circuit under test, the low impedance line should be connected to the right-hand terminal, since this terminal has the higher capacitance to ground.

c. ZERO adjustment. The ZERO adjustment may be used to adjust the electrical zero of the instrument to the desired value. Meter calibration is correct only when the meter needle is set to zero (amplifier output voltage is always proportional to meter reading).

d. NORMAL-EXPANDED switch. The NORMAL-EXPANDED switch provides two ranges of zero adjustment. NORMAL position is used when the meter needle has to be set critically within $\pm 10\%$ of end scale from zero. EXPANDED is used when it is desired to set a reference near the scale ends. Meter sensitivity is unaffected by the setting of this control.

e. Amplifier Output terminals. The amplifier output terminals, (figure 2-1) located on the rear of the 413A cabinet mount, and on both the front and rear of the 413AR rack mounted instrument, provide an output voltage proportional to meter deflection. End scale meter deflection produces 1 volt output with the same polarity as the input signal.

## 3-7. OPERATING INSTRUCTIONS.

3-8. The following is a step-by-step procedure for operating the 413A. When operating the 413A, be sure that the ambient temperature is within the limits specified in paragraph 2-10. Proceed as follows:

CAUTION

Do not overload this instrument. The amplifier input is not protected from extreme overload. Momentary overloads ten times full scale will not damage the instrument.

a. Turn the power switch ON and allow 5 minutes for the instrument to stabilize.

b. Set NORMAL-EXPANDED switch to the position desired.

c. Turn the RANGE (VOLTS) switch to the required level.

d. Adjust the ZERO control to the desired setting. (Zero offset, if any, remains constant regardless of the range setting.)

e. Connect the voltage to be measured to the input connectors.

3-9. OPERATION WITH A RECORDER. To obtain permanent records of 413A readings, connect a recorder to the dc amplifier output connector, and operate the 413A as directed in paragraph 3-7. The output of the 413A amplifier is 1-volt end scale; if necessary, externally attenuate the 413A output to match it with recorder sensitivity. Maximum rated load current from the 413A is 1 ma. A load resistance of less than 1000 ohms may cause the load current to exceed 1 ma and thus cause errors in meter indication and amplifier gain.

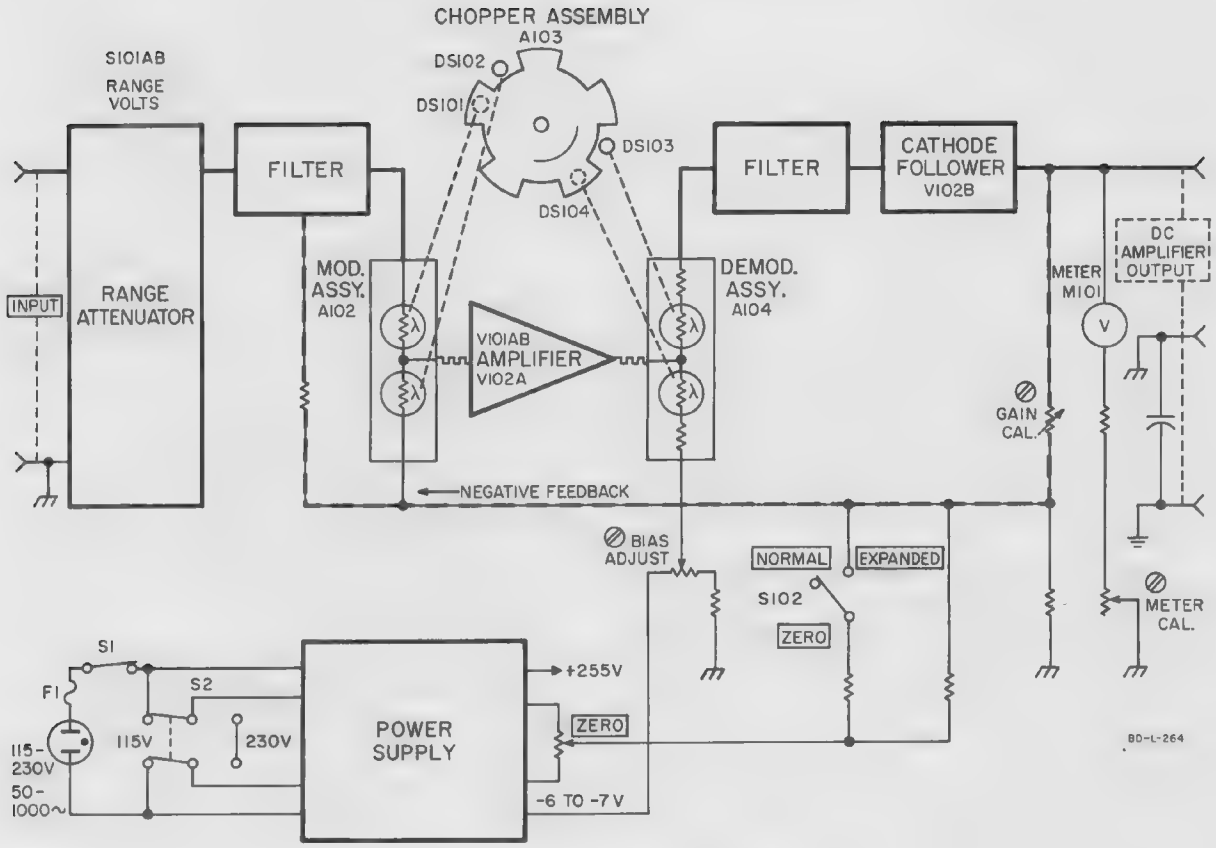



Figure 4-1. Model 413A Block Diagram

# SECTION IV
# PRINCIPLES OF OPERATION

## 4-1. GENERAL.

4-2. The 413A is a dc voltmeter which accomplishes amplification of the dc input voltage without the usual problems of dc drift etc., by first changing the dc to ac, amplifying it and then changing it back to dc for application to the meter circuit and amplifier output connector. Refer to figure 4-1 (block diagram) and to the schematic (figures 5-15 and 5-16) for the following discussion.

## 4-3. DC INPUT CIRCUITS.

4-4. The input voltage is first fed to range attenuator S101AB where it is attenuated according to the setting of the RANGE (VOLTS) control. The voltage is then fed through a low pass filter made up of R101-103 and C101-103 to a photoconductor modulator, A102. The filter attenuates any ac components present in the input voltage.

## 4-5. AC CIRCUITS.

4-6. MODULATOR. A synchronous motor, B101, drives a light interrupter which controls the resistance of the photoconductors (photosensitive resistors) in A102 modulator and A104 demodulator units. In order to simplify the following circuit explanation, the modulator will be discussed alone. However, this discussion applies to demodulator operation as well.

4-7. In figure 4-2, B101 has turned the light interrupter, and allowed the light source (DS102) to shine on photoconductor V1, lowering its resistance to a few thousand ohms. Since photoconductor V2 maintains its "dark" resistance of many megohms, the voltage to the amplifier will be about the same as the dc voltage applied to the modulator. In figure 4-3, however, B101 has turned the shutter assembly sufficiently to turn off the light source to V1 and turn on the light (DS101) to V2. Now the resistance of V1 will return to its high "dark" resistance, whereas the resistance of V2 will be very low. The voltage to the amplifier will now be some very low voltage determined by the ratio of the photoconductor resistances. This action continues resulting in a square-wave signal of 5/6 line frequency.

4-8. AC AMPLIFIER. The ac amplifier, consisting of V101AB and V102A, is a conventional circuit which amplifies the modulator output about 500,000 times. The output from V102A is fed to demodulator unit A104 which is synchronized with the modulator. The operation of the demodulator is similar to the modulator but its action is essentially the reverse; e.g. to change the square wave output from the amplifier back to dc.

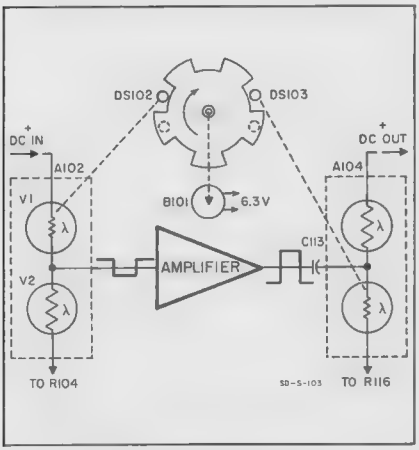



Figure 4-2. Modulator/Demodulator Operation (Phase One)

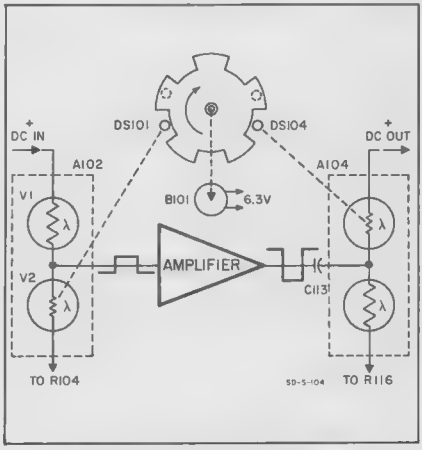



Figure 4-3. Modulator/Demodulator Operation (Phase Two)

## 4-9. DC OUTPUT CIRCUITS.

4-10. The output from the demodulator is filtered by C114-116 and R114-118 and fed to cathode follower V102B. Cathode follower bias is set by adjusting R116 Bias Adjust. The output of V102B is used for the following purposes:

a. For meter deflection. R123 is used to adjust the meter current to the correct value.

b. To provide a dc output voltage proportional to meter deflection. This voltage is available at the dc amplifier output terminals.

c. For feedback to the modulator assembly A102, and the filter network. The negative feedback, adjusted with R119 Gain Cal., stabilizes the dc gain of the modulator-amplifier-demodulator system to a value of 1111, thereby providing an output of 1 volt for an input of 0.9 millivolts.

## 4-11. POWER SUPPLY.

4-12. The 413A power supply is a conventional full-wave rectifier with resistors R1, R2, and zener diode CR1 in the power transformer center tap to develop the -6 to -7 volts for the cathode follower bias. Resistor R8, ZERO, adjusts meter zero by changing the dc bias of the modulator-amplifier-demodulator network. Switch S2 changes T1 primary circuit for 230-volt operation. A fuse of different rating must be used in case of 230-volt operation (see Table of Replaceable Parts).

# SECTION V
# MAINTENANCE

## 5-1. INTRODUCTION.

5-2. This section contains test and maintenance information for the Model 413A DC Null Voltmeter. A performance check is included (paragraph 5-40) that may be used to verify operation within published specifications. This check should be made with the instrument in its cabinet, and is a good test as part of routine maintenance or as a part of your incoming inspection.

## 5-3. TEST INSTRUMENTS REQUIRED.

5-4. Table 5-1 lists the test equipment that is required to complete the maintenance instructions in this section. Instruments other than those recommended may be used, provided their performance meets the basic requirements given in table 5-1.

## 5-5. CABINET REMOVAL.

5-6. To remove the 413A cabinet, proceed as follows:

a. Unplug power cord from the power source.

b. Remove the two retaining screws on the rear of the instrument (three screws for the rack mounted 413AR).

c. Slide the instrument chassis forward out of the cabinet. Bezel ring remains attached to the front panel.

CAUTION

Do not lubricate the RANGE (VOLTS) switch or touch the switch wafers with the fingers in the following procedures. Wear a pair of light cotton gloves when handling the switch, since skin oils and acids can contaminate the switch wafers and degrade instrument performance.

## 5-7. TROUBLESHOOTING.

5-8. GENERAL.

5-9. The following paragraph gives information to aid in the localization of troubles in the 413A. In most cases, a trouble may be localized to a section from

Table 5-1. Equipment Required

| Instrument Type | Minimum Required Specifications | Use | Recommended Instruments |
|---|---|---|---|
| Voltmeter Calibration Generator | Output Voltage Range: .001 to 300 volts<br>Signal Frequency: dc<br>Accuracy: ±0.25% | 413A Amplifier Calibration | ℗ Model 738AR Voltmeter Calibrator |
| Low Frequency Oscilloscope | Sensitivity: 0.01 volt/cm minimum<br>Frequency Response: flat down to at least 10 cps | For 10 cps hum measurements and modulator check | ℗ Model 120AR Oscilloscope |
| Electronic Voltmeter | Sensitivity: 0.05 volt full scale<br>Input Resistance: 10 megohms or higher | Troubleshooting and amplifier gain calibration | ℗ Model 412A or 413A Vacuum Tube Voltmeters |
| Variable Power Transformer | Variation: from at least 102 to 128 volts<br>Current Capabilities: at least 1 ampere<br>Monitor Voltmeter: accurate to at least ±1 volt | Power supply check | General Radio W10MT3A Metered Variac® Autotransformer |
| Ohmmeter | Accuracy: ±5%<br>Ranges: to at least 10 megohms full scale | Troubleshooting | ℗ Model 410B or 412A Vacuum Tube Voltmeters |
| Voltage Source | Voltage: between 1 and 2 volts | Amplifier Gain Calibration | Burgess HG3<br>Burgess No. 2, Size D flashlight cell or equivalent |

front panel indications. A good method is to follow the performance verification procedure (paragraph 5-40) until the trouble manifests itself as a reading that is out of the listed specifications. For example, if the instrument operates properly on all voltage ranges but .003, only R82, R84 or associated switch contacts and wiring can be faulty. A bad reading on all ranges indicates trouble in the modulator-amplifier-demodulator system, or in the power supply.

Note

The 413A is a sensitive instrument. If it gives unexpected readings on its lowest voltage ranges, it may be measuring thermoelectric voltages, etc., in addition to the expected voltage (see paragraph 3-3).

5-10. AMPLIFIER-POWER SUPPLY.

5-11. Amplifier and power supply operation is best checked by voltage readings and tube substitution. If tube substitution does not correct the difficulty, return the original tube to the instrument. If tubes are changed, refer to table 5-2 for any necessary adjustments. Voltages are indicated at various points on the schematic diagrams (figures 5-15 and 5-16); these are typical voltages and may vary somewhat from instrument to instrument.

5-12. CHOPPER ASSEMBLY.

5-13. Before the modulator or demodulator can be checked, it must be ascertained that the chopper assembly, A103, is functioning properly. Refer to figure 5-1 for location of parts in the following steps. Proceed as follows:

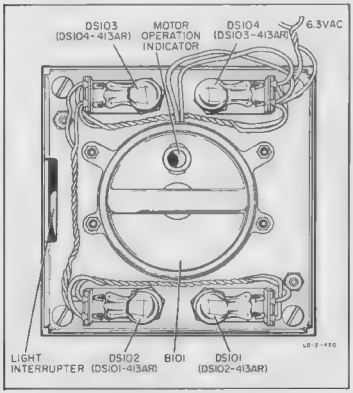



Figure 5-1. A103, Chopper Assembly

a. Remove cabinet (paragraph 5-5).

b. Check all four lamps (DS101-104) to make sure they glow when power is applied.

c. Check the light interrupter in the cut away portion of the chopper assembly to see if the chopper blades are rotating. A soldering aid may be inserted into the slot for a moment if necessary to check operation.

d. If the chopper blades are not turning, look at the motor operation indicator in the back of motor B101. If B101 is operating, the chopper blade is loose on its shaft. If not, check the 6.3 volt circuit to the motor.

5-14. MODULATOR.

5-15. To check modulator operation, proceed as follows:

a. Unplug the 413A from the power source, and remove the cabinet (paragraph 5-5).

b. Remove V101 and reconnect the 413A to the power source.

c. Connect a clip lead from the 413A input terminals to the center arm of R116, Bias Adjust Potentiometer.

d. Set RANGE (VOLTS) to .001.

e. Set oscilloscope input to DC.

f. Connect one lead of an 8.2-megohm resistor to oscilloscope signal connector (or probe). Using a jumper wire, connect the other resistor lead to the junction of R85 and S101D (point A in figure 5-5). Connect oscilloscope common lead to 413A common connector.

g. Observe amplitude of the dc voltage at point A.

h. Move oscilloscope probe (with resistor) to point B in figure 5-3.

i. Waveform should be similar to that shown in figure 5-2, and should have a peak-to-peak amplitude approximately equal to the deflection found in step g. Signal frequency should be 5/6 line frequency.

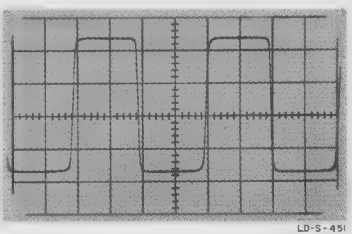



Figure 5-2. Approximate Chopper Waveform

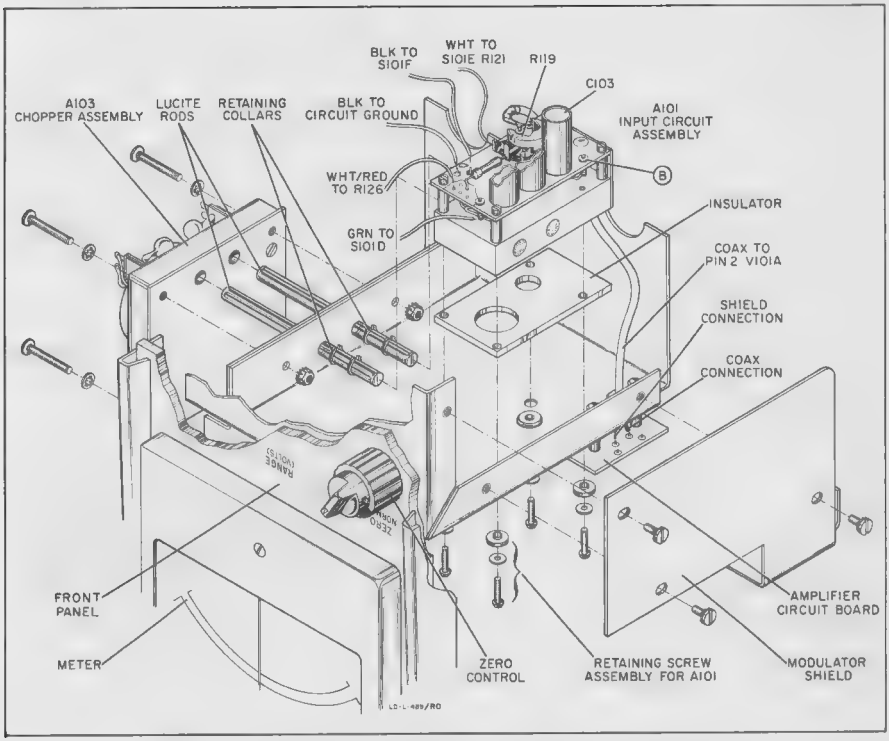



Figure 5-3. Exploded View, Showing Disassembly for Modulator Replacement

5-16. DEMODULATOR.

5-17. The demodulator assembly (A104) is located behind the meter between the main chassis and the power transformer (see figures 5-4 and 5-13). Proceed as follows:

a. Unplug the 413A from the power source and remove the cabinet (see paragraph 5-5).

b. Remove V102.

c. Remove DS103 (figure 5-1) from chopper assembly A103.

d. Connect a 1 μf capacitor across the input terminals of the ohmmeter.

e. Connect the ohmmeter common lead to the demodulator terminal which has the pink-orange lead connected to it.

f. Connect the other ohmmeter lead to the terminal which has the white-orange lead connected to it.

g. Plug the 413A into the power source and turn it ON.

h. Note resistance indicated on the ohmmeter. Typical resistance is between 1 and 2 megohms.

i. Turn the 413A off and unplug it from the power source.

j. Replace DS101 and remove DS102.

k. Connect the ohmmeter common lead to the demodulator terminal which has the brown-orange lead connected to it.

m. Connect the other lead from the ohmmeter to the terminal which has the white-orange lead connected to it.

n. Plug the 413A into the power source, turn it ON and note the resistance indicated on the ohmmeter. Typical resistance is between 1 and 2 megohms.

p. Turn the 413A off and replace DS102 and V102.

## 5-18. REPAIR AND REPLACEMENT.

5-19. GENERAL.

5-20. This paragraph is intended to simplify repair problems in the 413A. Tube replacement information is given, as well as repair procedures for the modulator, demodulator and RANGE (VOLTS) switch. Repair procedures should be followed carefully to assure correct operation of replacement parts. Replacing components on etched circuit boards requires extra care (see figure 5-11). After component replacement in the following paragraphs, refer to paragraph 5-29 (adjustments).

CAUTION

Do not lubricate the RANGE (VOLTS) switch or touch the switch wafers with the fingers in the following procedures. Wear a pair of light cotton gloves when handling the switch, since skin oils and acids can contaminate the switch wafers and degrade instrument performance.

5-21. MODULATOR REPLACEMENT.

5-22. Figure 5-3 shows necessary disassembly for modulator replacement. Proceed as follows:

a. Unplug the 413A from the power source.

b. Remove the cabinet (paragraph 5-5).

c. Disconnect all wires from the top of A101 as shown in figure 5-3.

d. Remove chopper assembly, A103, and slide the light rods out of A101.

Note

In the 413AR rack mount unit, it is not necessary to remove the chopper assembly. Perform step e and slide A101 away from the light rods.

e. Remove the four screws holding the input circuit assembly (A101) to the main chassis. When replacing this assembly, be sure to reseat the insulated washers (figure 5-3) in their proper positions.

f. Disconnect the green lead at A101.

g. Carefully unsolder the shielded cable (figure 5-3) from the amplifier circuit board (pin 2 and 3 of V101A). (A length of cable is normally supplied with the input circuit assembly. However, if it is more convenient, and the cable is known to be good, it may be disconnected at the input assembly circuit board.) In any case, avoid undue heat that might damage the inner conductor insulating material in the coax.

h. Reverse the above procedure to install the replacement assembly.

5-23. DEMODULATOR REPLACEMENT.

5-24. To replace demodulator assembly, A104, proceed as follows:

a. Turn the 413A off.

b. Remove the three leads connected to the demodulator.

c. Remove the two nuts from the demodulator mounting screws and remove the demodulator from the instrument. If it is necessary to get at the screw heads to remove the nuts, remove the four mounting screws from the chopper assembly and let the assembly hang by its leads.

d. Reverse the above procedure to install replacement assembly. Wire connection differs for the 413A cabinet mount and the 413AR rack mount. See figure 5-4 for wiring detail.

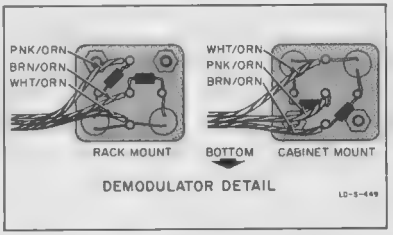



Figure 5-4. Cabinet/Rack Demodulator Differences

5-25. RANGE (VOLTS) SWITCH REPLACEMENT.

5-26. Figure 5-5 shows the location of all parts and wire destinations for the replacement of the RANGE (VOLTS) switch. The Model 413A should be checked for correct calibration after replacing this switch.

CAUTION

Make solder connections as quickly as possible when replacing components on the RANGE (VOLTS) switch. AVOID EXCESSIVE HEAT. Excessive heat will damage the switch wafers. Observe handling precautions described in paragraph 5-20.

5-27. TUBE REPLACEMENT.

5-28. If tubes are suspected of being defective, check them by substitution and replace only those which are defective. Table 5-2 gives any adjustments necessary after tube replacement.

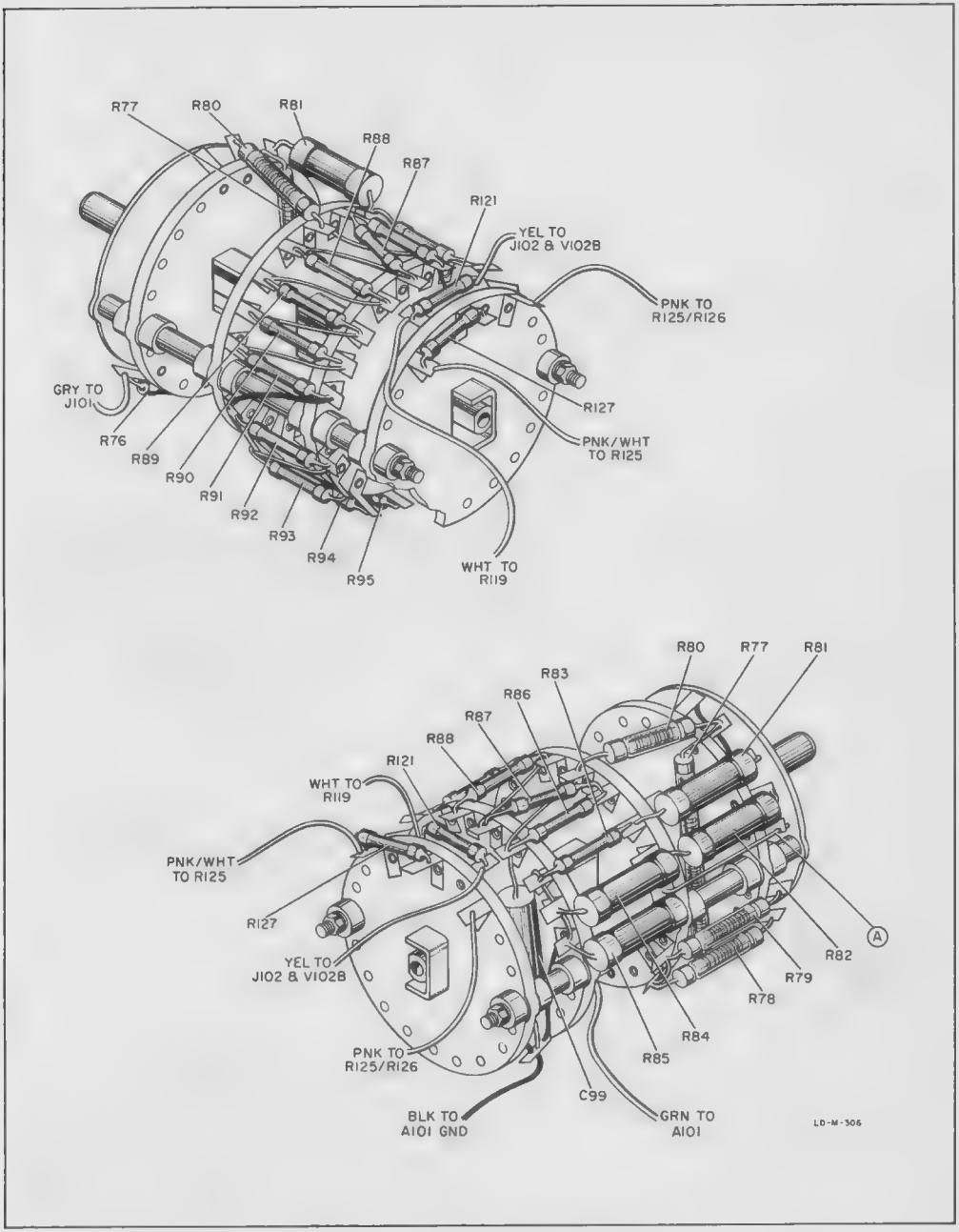



Figure 5-5. S101 Range (Volts) Switch Detail

Table 5-2. Tube Replacement

| Ref. Desig. | Tube Type | Adjustment | Para. Ref. |
|---|---|---|---|
| V101 | 12AX7 | Hum Balance | 5-33 |
| V102 | 6AU8 | Bias Adjust | 5-35 |
| V103 | 6X4 | | |
| V104 | 0A2 | None | |
| V105 | 0B2 | | |

## 5-29. ADJUSTMENTS.

5-30. The following is a complete adjustment procedure and should be made only if it has been definitely determined that the 413A is out of adjustment. After adjustment, refer to paragraph 5-40 to check instrument operation.

5-31. MECHANICAL ZERO ADJUSTMENT.

5-32. When the meter is properly zero-set the pointer rests over the zero calibration mark on the meter scale when the instrument is 1) at normal operating temperature. 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until the meter pointer is to the left of zero and moving to the right toward zero.

d. Continue to rotate adjustment screw clockwise; stop when the pointer is right on zero. If the pointer overshoots zero, repeat steps c and d.

e. When the pointer is exactly on zero rotate the adjustment screw approximately 15 degrees counterclockwise. This is enough to free the adjustment screw from the meter suspension. If the pointer moves during this step, you must repeat steps c through e.

5-33. HUM BALANCE.

a. Turn instrument on and allow a few minutes warmup.

b. Set RANGE (VOLTS) selector to 1.

c. Connect oscilloscope to the dc amplifier output connector as shown in figure 5-6.

d. Adjust Hum Bal. (R3), for minimum 10-cps signal as seen on oscilloscope. (If power-line frequency is 50 cps, adjust for minimum 8-1/3 cps signal.) See figure 5-13 for location of R3.

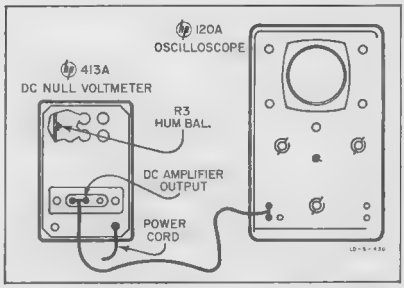



Figure 5-6. Hum Balance Test Setup

5-34. BIAS ADJUST.

a. Set RANGE (VOLTS) switch full clockwise -- one step beyond 1000.

b. Adjust Bias Adj. (R116), to set meter pointer to zero ±20% of end scale. R116 is located on instrument rear. This adjustment is not critical, since any deviation from zero is reduced more than 300 times when the RANGE (VOLTS) switch is on any operating position.

## 5-35. AMPLIFIER GAIN CALIBRATION AND METER CALIBRATION.

5-36. PRELIMINARY.

5-37. The following procedure sets up a standard of 1 volt for voltage comparison for use in the following procedures:

a. Connect a voltage calibration generator to a 313A or 412A test voltmeter and battery circuit as shown in figure 5-7. This test voltmeter will hereafter be called the accuracy indicator.

b. Set S1 in figure 5-7 to position 1.

c. Set voltmeter calibrator function switch to OFF.

d. Set accuracy indicator range switch to .03.

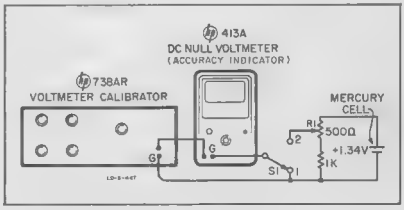



Figure 5-7. Preliminary Test Setup

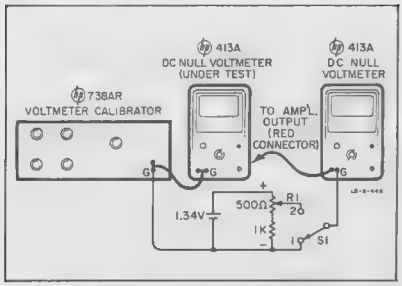



Figure 5-8. Amplifier Calibration Test Setup

e. If the accuracy indicator has no zero control, observe the meter reading. This reading will be used as the "zero error point".

f. If the accuracy indicator has a zero control (as in figures 5-7 and 5-8), adjust the ZERO control for zero on the meter. At the same time set S1 to position 2 and voltmeter calibrator function switch to DC+.

g. Adjust R1 for the same reading observed in steps e or f (zero error point). This accurately establishes one volt at the center arm of R1.

h. Each cardinal (numbered) point on the accuracy indicator scale is now 1%, giving a range of +3% for the accuracy indicator.

5-38. GAIN CALIBRATION.

5-39. The following procedure uses the standardized test setup from paragraph 5-37. Proceed as follows:

a. Connect the accuracy indicator and the voltmeter calibrator to the 413A under test as shown in figure 5-8.

Note

The rest of this procedure assumes that a DC Null Voltmeter such as the Model 413A is being used as the accuracy indicator.

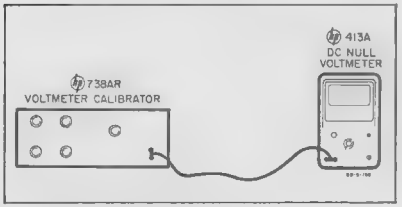



Figure 5-9. Performance Test (Voltmeter) Setup

b. Set S1 in figure 5-8 to position 1.

c. Set the voltmeter calibrator function switch to OFF and the range switches to provide a +1 volt output.

d. Set 413A RANGE (VOLTS) switch to 1.

e. Adjust 413A ZERO control to read zero on the accuracy indicator.

f. Set S1 in figure 5-8 to position 2 and set voltmeter calibrator function switch to DC+.

g. Adjust R119, Gain Cal., (on the 413A under test) for a reading of zero on the accuracy indicator.

h. Adjust R123, Meter Cal., for an end-scale reading of 1 volt on the 413A.

i. Repeat steps 7, 8, and 9 using positive test voltages ranging from 0.001 volts through 300 volts from the voltmeter calibrator. Set the 413A RANGE (VOLTS) switch to the appropriate range for each voltage. Record the error readings of all ranges, taking into account the algebraic sign of error observed.

j. Reverse the battery connection in the test setup in figure 5-8, and repeat step i using negative test voltages. If necessary, standardize the accuracy indicator for negative voltages. (Follow paragraph 5-37, steps a through i with battery connections reversed.)

k. Study the error readings and determine a new setting for R119, Gain Cal., that will result in the best overall error figures for the entire voltage range.

m. Adjust R119 for this new value on some convenient range.

n. The final setting must reduce error on any scale to less than ±1.5% on the accuracy indicator and ±2% of end scale on the 413A meter.

## 5-40. PERFORMANCE VERIFICATION.

5-41. The following procedure is to verify proper operation and should be accomplished with the instrument in its cabinet. This check may be made as a final test for routine maintenance or as a part of your incoming quality control inspection to verify listed specifications. If the instrument fails any of the following tests, refer to paragraph 5-29, Adjustment Procedure. Proceed as follows:

Note

The following procedures assume correct mechanical zero on the 413A meter (paragraph 5-31).

5-42. VOLTMETER.

a. Turn the voltmeter calibration generator on and allow a 20-minute warmup.

b. Switch the voltmeter calibrator function switch to OFF, and connect the output connectors to the 413A INPUT as shown in figure 5-9.

c. Connect the 413A to the variable power source, set line voltage to rated value (115 or 230 volts) and turn the 413A ON. Allow 15 minutes for the instrument to warm up.

d. Turn 413A RANGE (VOLTS) switch fully clockwise (one step past 1000), and observe the 413A meter.

e. Adjust R116, Bias Adjust, for a zero indication ±20% on the meter (see paragraph 5-34).

f. Switch 413A ZERO to NORMAL, and adjust the ZERO control for an exact zero reading on the 413A meter.

g. Switch 413A RANGE (VOLTS) to 300, and set voltmeter calibrator output to +300 volts dc.

WARNING

The 738AR Voltmeter Calibrator output is a constant voltage source and can be dangerous! Be careful not to touch the output leads without first tuning OUTPUT SELECTOR to OFF.

h. The 413A meter should read +300 volts ±2% of end scale.

i. Vary line voltage between 103 and 127 volts. Meter reading should be unaffected.

j. Repeat steps h and i for -300 volts.

k. Check end scale readings for the remaining ranges. Specifications are ±2% of end scale.

m. Switch 413A RANGE (VOLTS) to 1; set voltmeter calibrator range and function switches for 1 volt dc out.

n. Check meter tracking in 1/10 volt increments for both plus and minus input voltages. Meter tracking should be correct within ±2% of end scale.

Note

When checking the 413A on the .003 and .001 volt ranges, set the voltmeter calibrator selector switch to OFF and reset ZERO control for a meter reading of zero.

5-43. AC REJECTION.

a. With 413A INPUT open, set 413A RANGE (VOLTS) to .03. Set ZERO for a zero indication on the 413A meter.

b. Connect a source of 6.3 volts ac (with no dc level) across the 413A input. Any change in the 413A meter reading should be less than 1%.

5-44. AMPLIFIER OUTPUT.

a. Connect a voltmeter calibrator and the accuracy indicator (paragraph 5-37) to the 413A as shown in figure 5-10.

b. Switch accuracy indicator range switch to .03.

c. Set 413A RANGE (VOLTS) switch to 1.

d. Switch voltmeter calibrator function and range switches to +1 volt.

e. Accuracy indicator should indicate less than 1.5% error.

f. Repeat steps a to d for -1 volt.

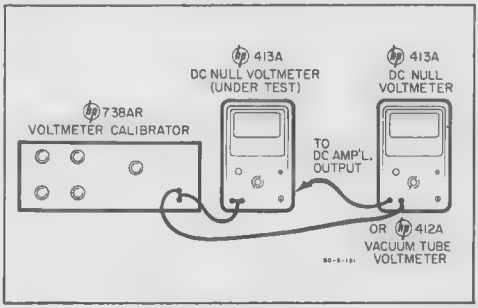



Figure 5-10. Performance Test (Amplifier) Setup

## SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

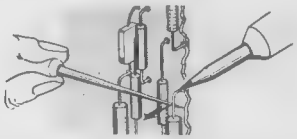
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

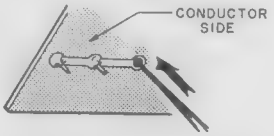
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

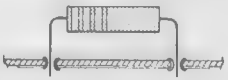
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



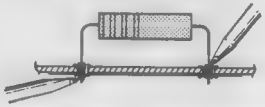
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.




3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

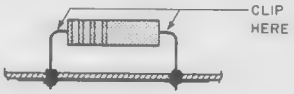


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

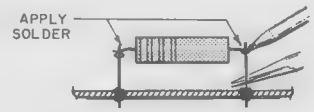


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.




2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.




This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-11. Servicing Etched Circuit Boards

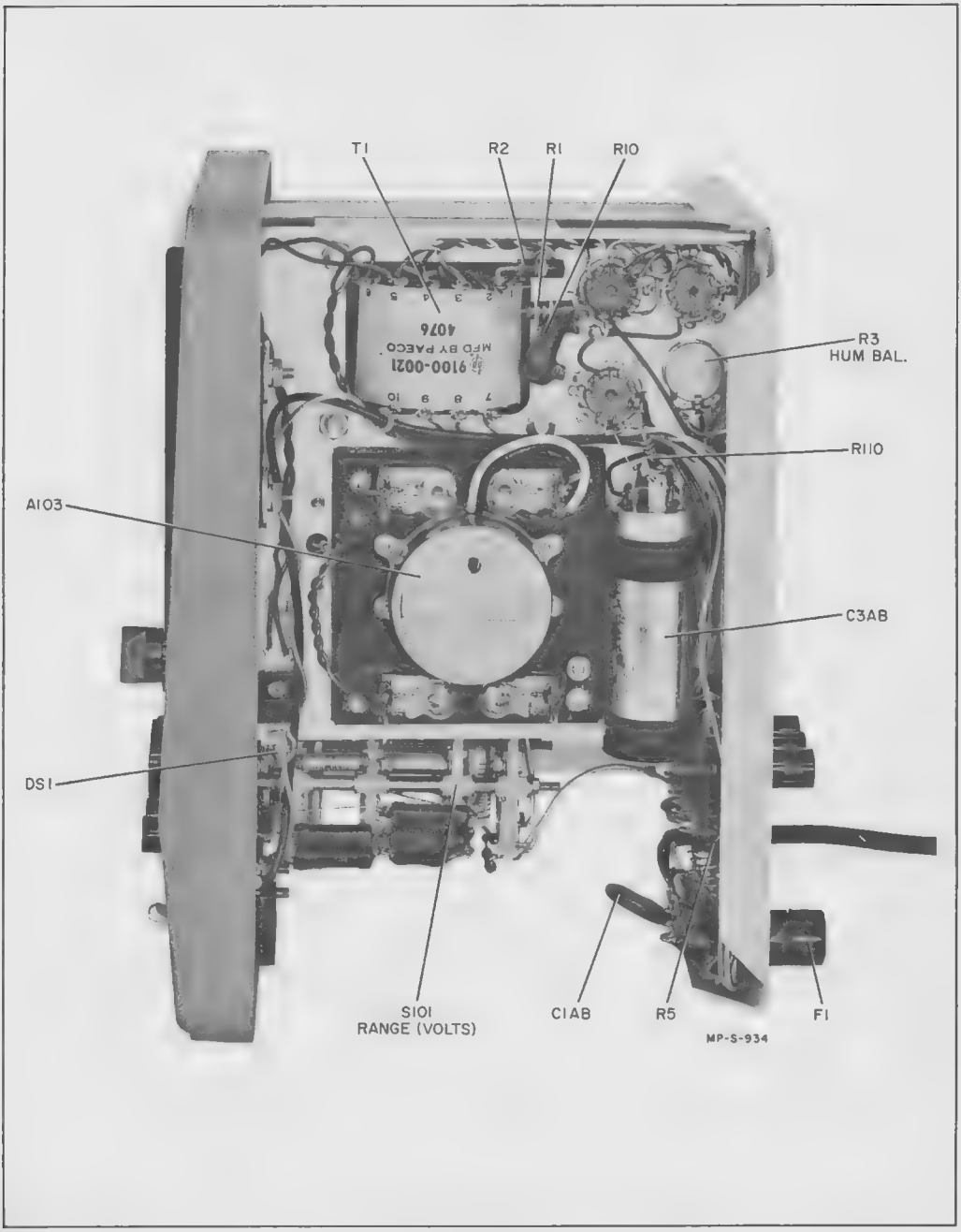



Figure 5-12. Model 413A Right Side View

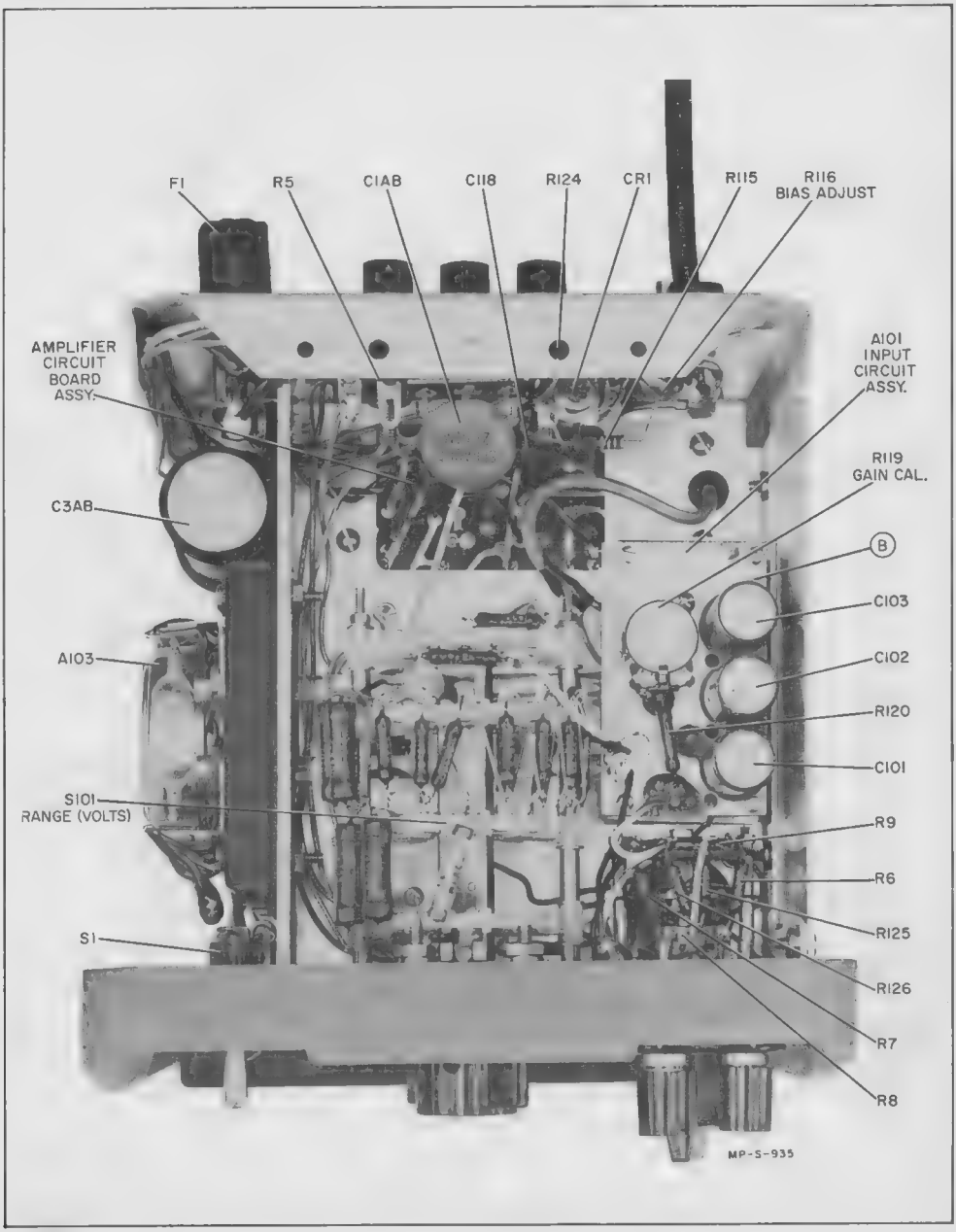
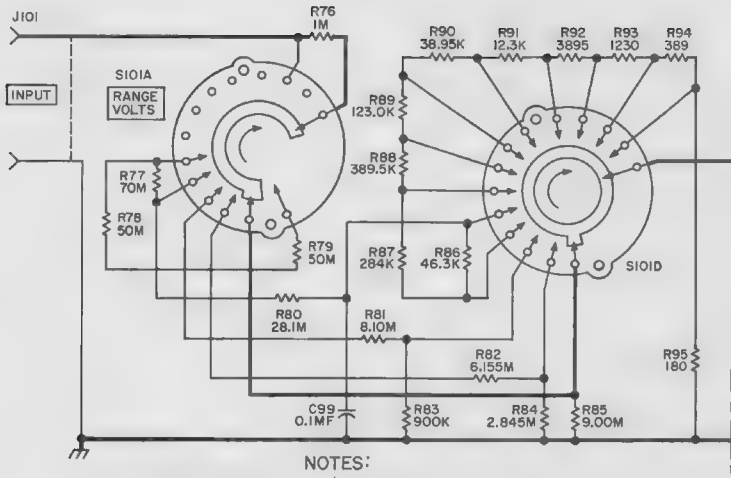
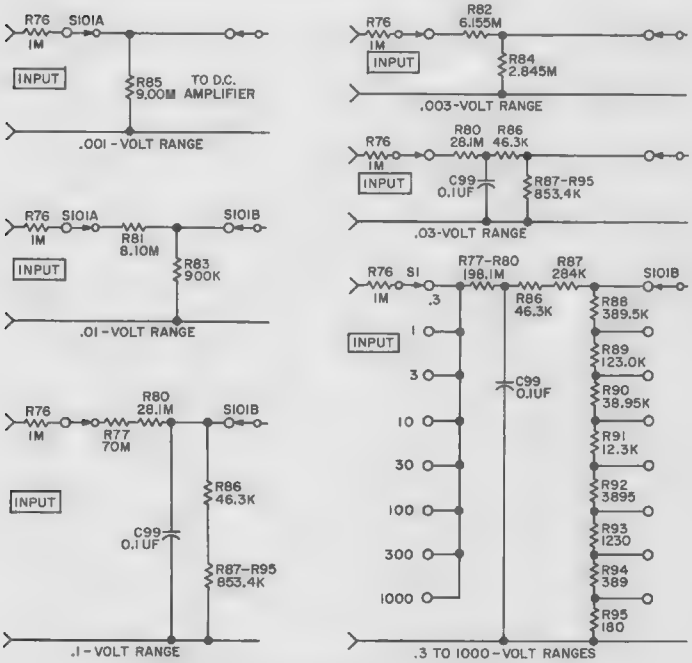



Figure 5-14. Model 413A Bottom View

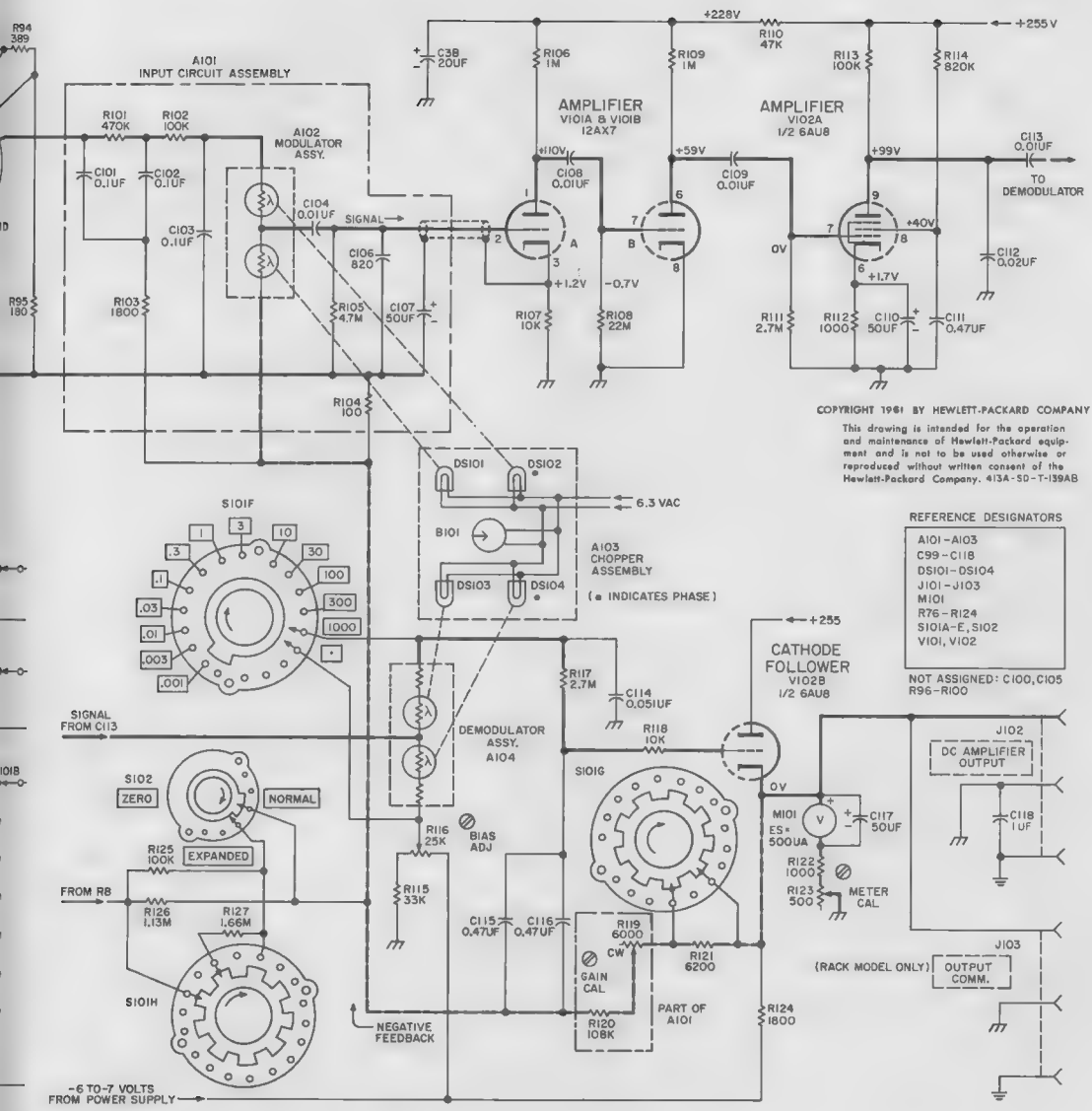



NOTES:

1. DC VOLTAGES REFERENCED TO ⏚ WITH LINE VOLTAGE AT 115 V AND NO METER DEFLECTION.
2. ALL RESISTANCE VALUES IN OHMS, CAPACITANCE IN PF UNLESS OTHERWISE NOTED.
3. ⏚ = FLOATING CHASSIS GROUND. ⏚ = CABINET GROUND.
4. SWITCHES SHOWN FULLY CCW VIEWED FROM FRONT PANEL.
5. SIMPLIFIED DIAGRAMS FOR S101A & S101B SHOWN BELOW.




SIMPLIFIED DIAGRAM OF S101A & S101B SWITCHING






REFERENCE DESIGNATORS

| |
|---|
| A101-A103 |
| C99-C118 |
| DS101-DS104 |
| J101-J103 |
| M101 |
| R76-R124 |
| S101A-E, S102 |
| V101, V102 |

NOT ASSIGNED: C100, C105
R96-R100

Figure 5-15. Model 413A DC Null Voltmeter

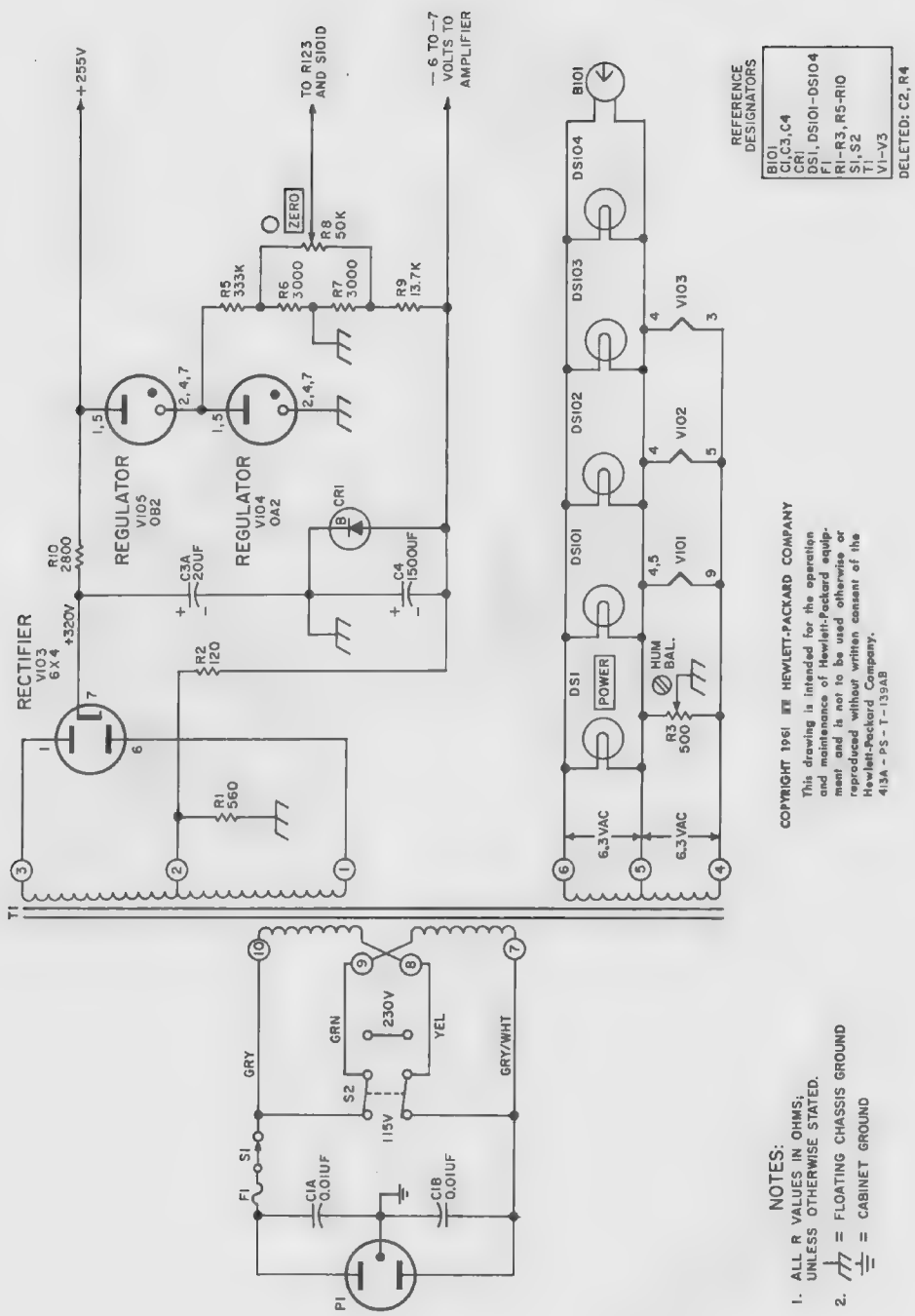



Figure 5-16. Power Supply

# SECTION VI
# REPLACEABLE PARTS

## 6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ⓗ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Typical manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

## 6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

### REFERENCE DESIGNATORS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | = assembly | F | = fuse | P | = plug | V | = vacuum tube, neon bulb, photocell, etc. |
| B | = motor | FL | = filter | Q | = transistor | W | = cable |
| C | = capacitor | J | = jack | R | = resistor | X | = socket |
| CR | = diode | K | = relay | RT | = thermistor | XF | = fuseholder |
| DL | = delay line | L | = inductor | S | = switch | XV | = tube socket |
| DS | = device signaling (lamp) | M | = meter | T | = transformer | XDS | = lampholder |
| E | = misc electronic part | | | | | | |

### ABBREVIATIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| bp | = bandpass | elect | = electrolytic | mtg | = mounting | rot | = rotary |
| bwo | = backward wave oscillator | encap | = encapsulated | my | = mylar | rms | = root-mean-square |
| | | | | | | rmo | = rack mount only |
| c | = carbon | f | = farads | NC | = normally closed | | |
| cer | = ceramic | fxd | = fixed | Ne | = neon | s-b | = slow-blow |
| cmo | = cabinet mount only | Ge | = germanium | NO | = normally open | Se | = selenium |
| coef | = coefficient | grd | = ground (ed) | NPO | = negative positive zero-zero temperature coefficient | sect | = section(s) |
| com | = common | h | = henries | | | Si | = silicon |
| comp | = composition | Hg | = mercury | nsr | = not separately replaceable | sl | = slide |
| conn | = connection | impg | = impregnated | | | td | = time delay |
| crt | = cathode-ray tube | incd | = incandescent | obd | = order by description | $TiO_2$ | = titanium dioxide |
| dep | = deposited | ins | = insulation (ed) | | | tog | = toggle |
| det | = detector | K | = kilo | p | = peak | tol | = tolerance |
| EIA | = Tubes and transistors selected for best performance will be supplied if ordered by ⓗ stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications | lin | = linear taper | pc | = printed circuit board | trim | = trimmer |
| | | log | = logarithmic taper | pf | = picofarads = $10^{-12}$ farads | twt | = traveling wave tube |
| | | m | = milli = $10^{-3}$ | pp | = peak-to-peak | var | = variable |
| | | M | = megohms | piv | = peak inverse voltage | w/ | = with |
| | | ma | = milliamperes | pos | = position(s) | W | = watts |
| | | minat | = miniature | poly | = polystyrene | ww | = wirewound |
| | | mfg | = metal film on glass | pot | = potentiometer | w/o | = without |
| | | mfr | = manufacturer | rect | = rectifier | * | = optimum value selected at factory, average value shown (part may be omitted) |

01194-2

Table 6-1. Reference Designation Index

| Circuit Reference | Stock No. | Description # | Note |
|---|---|---|---|
| A1 thru A100 | | Not assigned | |
| A101 | 412A-58A | Assy, input circuit, includes:<br>A102 R101 thru R105<br>C101 thru C104 R119<br>C106 R120<br>C107 | |
| A102 | 412A-95A | Assy, modulator | |
| A103 | 425A-97A | Assy, chopper: includes<br>B101, DS101 thru DS104 | |
| A104 | 412A-23B | Assy, demodulator | |
| A105 | 413A-19A | Assy, range switch: includes<br>C99, R76 thru R95, R121, R127, S101 | |
| A106 | 413A-19B | Assy, switch, zero: includes<br>R6 thru R9, R125, R126, S102 | |
| B1 thru B100 | | Not assigned | |
| B101 | 3140-0013 | Motor: 6.3 VAC | |
| C1A/B | 0150-0119 | C: fxd, cer, 0.01 uf/sect, ±20%, 250 vdcw | |
| C2 | | Not assigned | |
| C3A/B | 0180-0086 | C: fxd, elect, 2 sect, 20 uf/sect, 450 vdcw | |
| C4 | 0180-0054 | C: fxd, elect, 1500 uf, 10 vdcw | |
| C5 thru C98 | | Not assigned | |
| C99 | 0170-0019 | C: fxd, my, 0.1 uf ± 5%, 200 vdcw | |
| C100 | | Not assigned | |
| C101 thru C103 | 0170-0030 | C: fxd, poly, 0.1 uf ± 1%, 50 vdcw | |
| C104 | 0170-0029 | C: fxd, poly, 0.01 uf ± 10%, 50 vdcw | |
| C105 | | Not assigned | |
| C106 | 0140-0010 | C: fxd, mica, 820 pf ± 10%, 500 vdcw | |
| C107 | 0180-0033 | C: fxd, elect, 50 uf, 6 vdcw | |
| C108, 109 | 0150-0012 | C: fxd, cer, 0.01 uf ± 20%, 1000 vdcw | |
| C110 | 0180-0033 | C: fxd, elect, 50 uf, 6 vdcw | |
| C111 | 0160-0015 | C: fxd, paper, 0.47 uf ± 10%, 200 vdcw | |
| C112 | 0150-0024 | C: fxd, cer, 0.02 uf +80%, -20%, 600 vdcw | |
| C113 | 0150-0012 | C: fxd, cer, 0.01 uf ± 20%, 1000 vdcw | |

# See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

| Circuit Reference | Stock No. | Description # | Note |
|---|---|---|---|
| C114 | 0170-0003 | C: fxd, my, 0.051 uf ± 10%, 200 vdcw | |
| C115, 116 | 0160-0015 | C: fxd, paper, 0.47 uf ± 10%, 200 vdcw | |
| C117 | 0180-0105 | C: fxd, elect, 50 uf, 25 vdcw | |
| C118 | 0170-0022 | C: fxd, my, 0.1 uf ± 20%, 600 vdcw | |
| CR1 | G-31G-7H | Diode: breakdown | |
| DS1 | 2140-0012 | Lamp, minat: 2 pin, no. 12 | |
| DS2 thru DS100 | | Not assigned | |
| DS101 thru DS104 | 2140-0012 | Lamp, minat: 2 pin, no. 12 | |
| F1 | 2110-0020 | Fuse, cartridge: 0.8 amp, s-b (for 115V operation) | |
| | 2110-0018 | Fuse, cartridge: 0.25 amp, s-b (for 230V operation) | |
| J1 thru J100 | | Not assigned | |
| J101 | AC-10C | Binding post: black | |
| | AC-10D | Binding post: red | |
| | AC-54A | Insulator: binding post, black, 2 hole | |
| | AC-54E | Insulator: binding post, black, 2 hole | |
| J102 | AC-10C | Binding post: black | |
| | AC-10C | Binding post: black | |
| | AC-10D | Binding post: red | |
| | AC-54B | Insulator: binding post, black, 3 hole | |
| | AC-54F | Insulator: binding post, black, 3 hole | |
| J103 | AC-10C | Binding post: black (rmo) | |
| | AC-10C | Binding post: black (rmo) | |
| | AC-10D | Binding post: red (rmo) | |
| | AC-54B | Insulator: binding post, black, 3 hole (rmo) | |
| | AC-54F | Insulator: binding post, black, 3 hole (rmo) | |
| M1 thru M100 | | Not assigned | |
| M101 | 413A-81A | Meter, calibrated | |
| P1 | 8120-0050 | Cord, power: w/NEMA plug | |
| R1 | 0690-5611 | R: fxd, comp, 560 ohms ± 10%, 1W | |
| R2 | 0690-1211 | R: fxd, comp, 120 ohms ± 10%, 1 W | |

# See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

| Circuit Reference | ℗ Stock No. | Description# | Note |
|---|---|---|---|
| R3 | 2100-0078 | R: var, ww, lin, 500 ohms ± 30%, 3/10W | |
| R4 | | Not assigned | |
| R5 | 0727-0233 | R: fxd, dep c, 333K ohms ± 10%, 1/2 W | |
| R6, R7 | 0727-0124 | R: fxd, dep c, 3K ohms ± 1%, 1/2 W | |
| R8 | | nsr; part of S102 | |
| R9 | 0727-0167 | R: fxd, dep c, 13.7K ohms ± 1%, 1/2 W | |
| R10 | 0813-0018 | R: fxd, ww, 2.8K ohms ± 10%, 5W | |
| R11 thru R75 | | Not assigned | |
| R76 | 0727-0274 | R: fxd, dep c, 1 M ± 1%, 1/2 W | |
| R77 | 0733-0014 | R: fxd, dep c, 70M ± 1/2%, 2W | |
| R78, 79 | 0730-0150 | R: fxd, dep c, 50M ± 1/2%, 1W | |
| R80 | 0730-0149 | R: fxd, dep c, 28.1M ± 1/2%, 1W | |
| R81 | 0730-0134 | R: fxd, dep c, 8.1M ± 1/2%, 1W | |
| R82 | 0730-0128 | R: fxd, dep c, 6.155M ± 1/2%, 1W | |
| R83 | 0727-0262 | R: fxd, dep c, 900K ohms ± 1/2%, 1/2W | |
| R84 | 0730-0117 | R: fxd, dep c, 2.845M ± 1/2%, 1W | |
| R85 | 0730-0139 | R: fxd, dep c, 9M ± 1/2%, 1W | |
| R86 | 0727-0192 | R: fxd, dep c, 46.3K ohms ± 1/2%, 1/2W | |
| R87 | 0727-0231 | R: fxd, dep c, 284K ohms ± 1/2%, 1/2W | |
| R88 | 0727-0239 | R: fxd, dep c, 389.5K ohms ± 1/2%, 1/2W | |
| R89 | 0727-0215 | R: fxd, dep c, 123K ohms ± 1/2%, 1/2W | |
| R90 | 0727-0188 | R: fxd, dep c, 38.95K ohms ± 1/2%, 1/2W | |
| R91 | 0727-0164 | R: fxd, dep c, 12.3K ohms ± 1/2%, 1/2W | |
| R92 | 0727-0130 | R: fxd, dep c, 3895 ohms ± 1/2%, 1/2W | |
| R93 | 0727-0106 | R: fxd, dep c, 1230 ohms ± 1/2%, 1/2W | |
| R94 | 0727-0070 | R: fxd, dep c, 389 ohms ± 1/2%, 1/2W | |
| R95 | 0727-0051 | R: fxd, dep c, 180 ohms ± 1/2%, 1/2W | |
| R96 thru R100 | | Not assigned | |
| R101 | 0687-4741 | R: fxd, comp, 470K ohms ± 10%, 1/2W | |
| R102 | 0687-1041 | R: fxd, comp, 100K ohms ± 10%, 1/2W | |

# See introduction to this section

Table 6-2. Reference Designation Index (Cont'd)

| Circuit Reference | Stock No. | Description # | Note |
|---|---|---|---|
| R103 | 0687-1821 | R: fxd, comp, 1.8K ohms ± 10%, 1/2W | |
| R104 | 0727-0043 | R: fxd, dep c, 100 ohms ± 1%, 1/2W | |
| R105 | 0687-4751 | R: fxd, comp, 4.7M ± 10%, 1/2W | |
| R106 | 0687-1051 | R: fxd, comp, 1M ± 10%, 1/2W | |
| R107 | 0687-1031 | R: fxd, comp, 10K ohms ± 10%, 1/2W | |
| R108 | 0687-2261 | R: fxd, comp, 22M ± 10%, 1/2W | |
| R109 | 0687-1051 | R: fxd, comp, 1M ± 10%, 1/2W | |
| R110 | 0687-4731 | R: fxd, comp, 47K ohms ± 10%, 1/2W | |
| R111 | 0687-2751 | R: fxd, comp, 2.7M ± 10%, 1/2W | |
| R112 | 0687-1021 | R: fxd, comp, 1K ohms ± 10%, 1/2W | |
| R113 | 0687-1041 | R: fxd, comp, 100K ohms ± 10%, 1/2W | |
| R114 | 0687-8241 | R: fxd, comp, 820K ohms ± 10%, 1/2W | |
| R115 | 0687-3331 | R: fxd, comp, 33K ohms ± 10%, 1/2W | |
| R116 | 2100-0009 | R: var, comp, 25K ohms ± 20%, 1/3W | |
| R117 | 0687-2751 | R: fxd, comp, 2.7M ± 10%, 1/2W | |
| R118 | 0687-1031 | R: fxd, comp, 10K ohms ± 10%, 1/2W | |
| R119 | 2100-0136 | R: var, comp, lin, 6K ohms ± 20%, 3/10W | |
| R120 | 0727-0209 | R: fxd, dep c, 108K ohms ± 1%, 1/2W | |
| R121 | 0727-0142 | R: fxd, dep c, 6.2K ohms ± 10%, 1/2W | |
| R122 | 0727-0100 | R: fxd, dep c, 1K ohms ± 1%, 1/2W | |
| R123 | 2100-0022 | R: var, ww, lin, 500 ohms ± 20%, 1W | |
| R124 | 0687-1821 | R: fxd, comp, 1.8K ohms ± 10%, 1/2 W | |
| R125 | 0727-0208 | R: fxd, dep c, 100K ohms ± 1%, 1/2W | |
| R126 | 0727-0278 | R: fxd, dep c, 1.13M ± 1%, 1/2W | |
| R127 | 0727-0283 | R: fxd, dep c, 1.66M ± 1%, 1/2W | |
| S1 | 3101-0001 | Switch, tog: SPST | |
| S2 | 3101-0033 | Switch, sl: DPDT | |
| S3 thru S100 | | Not assigned | |
| S101 | | nsr; part of range switch assy, A105 | |
| S102 | 3100-0290 | Switch, rot: 1 sect, 2 pos, w/R8 var resistor | |

# See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

| Circuit Reference | Stock No. | Description # | Note |
|---|---|---|---|
| T1 | 9100-0021 | Transformer, power | |
| V1 thru V100 | | Not assigned | |
| V101 | 1932-0030 | Tube, electron: 12AX7 | |
| V102 | 1933-0007 | Tube, electron: 6AU8 | |
| V103 | 1930-0016 | Tube, electron: 6X4 | |
| V104 | 1940-0004 | Tube, electron: 0A2 | |
| V105 | 1940-0007 | Tube, electron: 0B2 | |
| XDS1 | 1450-0022 | Lampholder (rmo) | |
| | 1450-0043 | Lampholder (cmo) | |
| XF1 | 1400-0084 | Fuseholder | |
| XV1 thru XV 100 | | Not assigned | |
| XV101 | 1200-0048 | Socket, tube: 9 pin | |
| XV102 | 1200-0059 | Socket, tube: 9 pin, minat | |
| XV103 thru XV105 | 1200-0009 | Socket, tube: 7 pin, minat | |
| | | MISCELLANEOUS | |
| | G-74G | Knob, black: 1 in. ZERO CONTROL | |
| | G-74N | Knob, bar w/arrow RANGE (volts) SWITCH | |
| | G-74AT | Knob, red: 3/4 in. bar w/arrow NORMAL EXPAND SWITCH | |
| | 412A-37A | Light rod: modulator (cmo) | |
| | 412A-37B | Light rod: modulator (rmo) | |
| | 412A-65A | Assy, amplifier | |
| | 412A-65A-1 | Circuit board, amplifier: includes<br>C108 thru C110<br>C112<br>C113<br>R106 thru R109<br>R111 thru R114<br>V101<br>V102 | |

# See introduction to this section

Table 6-2. Replaceable Parts

| Stock No. | Description # | Mfr. | Mfr. Part No. | TQ | RS | | |
|---|---|---|---|---|---|---|---|
| AC-10C | Binding post: black<br>(cmo)<br>(rmo) | 28480 | AC-10C | <br>3<br>5 | <br>1 | | |
| AC-10D | Binding post: red<br>(cmo)<br>(rmo) | 28480 | AC-10D | <br>2<br>3 | <br>1 | | |
| AC-54A | Insulator: Binding post, black, 2 hole | 28480 | AC-54A | 1 | 0 | | |
| AC-54B | Insulator: Binding post, black, 3 hole<br>(cmo)<br>(rmo) | 28480 | AC-54B | <br>1<br>2 | <br>0 | | |
| AC-54E | Insulator: Binding post, black, 2 hole | 28480 | AC-54E | 1 | 0 | | |
| AC-54F | Insulator: Binding post, black, 3 hole<br>(cmo)<br>(rmo) | 28480 | AC-54F | <br>1<br>2 | <br>0 | | |
| G-31G-7H | Diode: breakdown | 28480 | G-31G-7H | 1 | 1 | | |
| 412A-23B | Assy, demodulator | 28480 | 412A-23B | 1 | 1 | | |
| 412A-58A | Assy, input circuit, includes: A102, C101 thru C104, C106, C107, R101 thru R105, R119, R120 | 28480 | 412A-58A | 1 | 1 | | |
| 412A-95A | Assy, modulator | 28480 | 412A-95A | 1 | 1 | | |
| 413A-19A | Assy switch, range: includes: C99, R76 thru R95, R121, R127, S101 | 28480 | 413A-19A | 1 | 1 | | |
| 413A-19B | Assy switch, zero: includes: R6 thru R9, R125, R126, S102 | 28480 | 413A-19B | 1 | 1 | | |
| 413A-81A | Meter, calibrated | 28480 | 413A-81A | 1 | 1 | | |
| 425A-97A | Assy chopper: includes B101, DS101 thru DS104 | 28480 | 425A-97A | 1 | 1 | | |
| 0140-0010 | C: fxd, mica, 820 pf ± 10%, 500 vdcw | 76433 | RCM20B821K | 1 | 1 | | |
| 0150-0012 | C: fxd, cer, 0.01 uf ± 20%, 1000 vdcw | 56289 | 29C214A3-H-1038 | 3 | 1 | | |
| 0150-0024 | C: fxd, cer, 0.02 uf +80% -20%, 600 vdcw | 91418 | B.02 GMV | 1 | 1 | | |
| 0150-0119 | C: fxd,cer, 2 sect., 0.01 uf/sect ± 20%,250 vdcw | 71590 | DA171CB | 1 | 1 | | |
| 0160-0015 | C: fxd, paper, 0.47 uf ± 10%, 200 vdcw | 56289 | 109P47492 | 3 | 1 | | |
| 0170-0003 | C: fxd, my, 0.051 uf ± 10%, 200 vdcw | 00853 | 33M02151 | 1 | 1 | | |
| 0170-0019 | C: fxd, my, 0.1 uf ± 5%, 200 vdcw | 84411 | 620S | 1 | 1 | | |
| 0170-0022 | C: fxd, my, 0.1 uf ± 20%, 600 vdcw | 56289 | S92684 | 1 | 1 | | |
| 0170-0029 | C: fxd, poly, 0.01 uf ± 10%, 50 vdcw | 56289 | 114P1039R5S2 | 1 | 1 | | |
| 0170-0030 | C: fxd, poly, 0.1 uf ± 10%, 50 vdcw | 56289 | Type 114P<br>Style T15 | 3 | 1 | | |

# See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

| Stock No. | Description# | Mfr. | Mfr. Part No. | TQ | RS | | |
|---|---|---|---|---|---|---|---|
| 0180-0033 | C: fxd, elect, 50 uf, 6 vdcw | 56289 | 30D133A1 | 2 | 1 | | |
| 0180-0054 | C: fxd, elect, 1500 uf, 10 vdcw | 56289 | D32495 | 1 | 1 | | |
| 0180-0086 | C: fxd, elect, 2 sect, 20 uf/sect, 450 vdcw | 00853 | Type PL1 | 1 | 1 | | |
| 0180-0105 | C: fxd, elect, 50 uf, 25 vdcw | 56289 | S97441 | 1 | 1 | | |
| 0687-1021 | R: fxd, comp, 1K ohms ± 10%, 1/2W | 01121 | EB1021 | 1 | 1 | | |
| 0687-1031 | R: fxd, comp, 10K ohms ± 10%, 1/2W | 01121 | EB1031 | 2 | 1 | | |
| 0687-1041 | R: fxd, comp, 100K ohms ± 10%, 1/2W | 01121 | EB1041 | 2 | 1 | | |
| 0687-1051 | R: fxd, comp, 1M ± 10%, 1/2W | 01121 | EB1051 | 2 | 1 | | |
| 0687-1821 | R: fxd, comp, 1.8K ohms ± 10%, 1/2W | 01121 | EB1821 | 2 | 1 | | |
| 0687-2261 | R: fxd, comp, 22M ± 10%, 1/2W | 01121 | EB2261 | 1 | 1 | | |
| 0687-2751 | R: fxd, comp, 2.7M ± 10%, 1/2W | 01121 | EB2751 | 2 | 1 | | |
| 0687-3331 | R: fxd, comp, 33K ohms ± 10%, 1/2W | 01121 | EB3331 | 1 | 1 | | |
| 0687-4731 | R: fxd, comp, 47K ohms ± 10%, 1/2W | 01121 | EB4731 | 1 | 1 | | |
| 0687-4741 | R: fxd, comp, 470K ohms ± 10%, 1/2W | 01121 | EB4741 | 1 | 1 | | |
| 0687-4751 | R: fxd, comp, 4.7 m ± 10%, 1/2W | 01121 | EB4751 | 1 | 1 | | |
| 0687-8241 | R: fxd, comp, 820K ohms ± 10%, 1 /2W | 01121 | EB8241 | 1 | 1 | | |
| 0690-1211 | R: fxd, comp., 120 ohms ± 10%, 1W | 01121 | GB1211 | 1 | 1 | | |
| 0690-5611 | R: fxd, comp, 560 ohms ± 10%, 1W | 01121 | GB5611 | 1 | 1 | | |
| 0727-0043 | R: fxd, dep c, 100 ohms ± 1%, 1/2W | 19701 | DC 1/2 BR5, obd# | 1 | 1 | | |
| 0727-0051 | R: fxd, dep c, 180 ohms ± 1/2W | 19701 | DC1/2 AR5, obd# | 1 | 1 | | |
| 0727-0070 | R: fxd, dep c, 389 ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0100 | R: fxd, dep c, 1K ohms ± 1%, 1/2W | 19701 | DC 1/2 CR5, obd# | 1 | 1 | | |
| 0727-0106 | R: fxd, dep c, 1.23K ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0124 | R: fxd, dep c, 3K ohms ± 1%, 1/2 W | 19701 | DC 1/2 CR5, obd# | 2 | 1 | | |
| 0727-0130 | R: fxd, dep c, 3895 ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0142 | R: fxd, dep c, 6.2K ohms ± 1%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0164 | R: fxd, dep c, 12.3K ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0167 | R: fxd, dep c, 13.7K ohms ± 1%, 1/2W | 19701 | DC 1/2 CR5, obd# | 1 | 1 | | |
| 0727-0188 | R: fxd, dep c, 38,950 ohms, ±1%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0192 | R: fxd, dep c, 46.3K ohms ± 1/2%, 1/2W | 19701 | DC 1/2 CR5, obd# | 1 | 1 | | |

# See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

| Stock No. | Description # | Mfr. | Mfr. Part No. | TQ | RS | | |
|---|---|---|---|---|---|---|---|
| 0727-0208 | R: fxd, dep c, 100K ohms ± 1%, 1/2W | 19701 | DC 1/2 CR5, obd# | 1 | 1 | | |
| 0727-0209 | R: fxd, dep c, 108K ohms ± 1%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0215 | R: fxd, dep c, 123K ohms ± 1/2%, 1/2 W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0231 | R: fxd, dep c, 284K ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0233 | R: fxd, dep c, 333K ohms ± 1%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0239 | R: fxd, dep c, 389.5K ohms ± 1/2%, 1/2 W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0262 | R: fxd, dep c, 900K ohms ± 1/2%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0274 | R: fxd, dep c, 1M ± 1%, 1/2W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0727-0278 | R: fxd, dep c, 1.13M ± 1%, 1/2 W | 19701 | DC 1/2 CR5, obd# | 1 | 1 | | |
| 0727-0283 | R: fxd, dep c, 1.66M ± 1%, 1/2 W | 19701 | DC 1/2 AR5, obd# | 1 | 1 | | |
| 0730-0117 | R: fxd, dep c, 2.845 M ± 1%, 1W | 19701 | DC 1 R5, obd# | 1 | 1 | | |
| 0730-0128 | R: fxd, dep c, 6.155 M ± 1%, 1W | 19701 | DC 1 R5, obd# | 1 | 1 | | |
| 0730-0134 | R: fxd, dep c, 8.1 M ± 1/2%, 1W | 19701 | DC 1 R5, obd# | 1 | 1 | | |
| 0730-0139 | R: fxd, dep c, 9 M ± 1/2%, 1W | 19701 | DC 1 R5, obd# | 1 | 1 | | |
| 0730-0149 | R: fxd, dep c, 28.1 M ± 1/2%, 1W | 03888 | PT1000, obd# | 1 | 1 | | |
| 0730-0150 | R: fxd, dep c, 50M ± 1/2%, 1W | 03888 | PT1000, obd# | 2 | 1 | | |
| 0733-0014 | R: fxd, dep c, 70M ± 1%, 2W | 03888 | PT2000, obd# | 1 | 1 | | |
| 0813-0018 | R: fxd, ww, 2.8K ohms ± 10%, 5W | 35434 | C-5-2800 | 1 | 1 | | |
| 1200-0009 | Socket, tube: 7 pin, minat | 91662 | 316PH-3702 | 3 | 1 | | |
| 1200-0048 | Socket, tube: 9 pin | 91662 | 3908-2-4 | 1 | 1 | | |
| 1200-0059 | Socket, tube: 9 pin, minat | 71785 | 121-51-11-082 | 1 | 1 | | |
| 1400-0084 | Fuseholder | 75915 | 342014 | 1 | 1 | | |
| 1450-0022 | Lampholder (rmo) | 72765 | 2020-AE | 1 | 1 | | |
| 1450-0043 | Lampholder (cmo) | 0000W | | | | | |
| 1930-0016 | Tube, electron: 6x4 | 80131 | 6x4 | 1 | 1 | | |
| 1932-0030 | Tube, electron: 12AX7 | 80131 | 12AX7 | 1 | 1 | | |
| 1933-0007 | Tube, electron: 6AU8 | 80131 | 6AU8 | 1 | 1 | | |
| 1940-0004 | Tube, electron: OA2 | 80131 | OA2 | 1 | 1 | | |
| 1940-0007 | Tube, electron: OB2 | 80131 | OB2 | 1 | 1 | | |
| 2100-0009 | R: var, comp, 25K ohms ± 20%, 1/3W | 11237 | Type 45, obd# | 1 | 1 | | |

# See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

| Stock No. | Description | Mfr. | Mfr. Part No. | TQ | RS | | |
|---|---|---|---|---|---|---|---|
| 2100-0022 | R: var, ww, lin, 500 ohms ± 20%, 1W | 11236 | Type 112, obd# | 1 | 1 | | |
| 2100-0078 | R: var, ww, lin, 500 ohms ± 30%, 3/10W | 11237 | 70C3837 | 1 | 1 | | |
| 2100-0136 | R: var, comp, lin, 6K ohms ± 20%, 3/10W | 11237 | Type 70, obd# | 1 | 1 | | |
| 2110-0018 | Fuse, cartridge: 0.25 amp, s-b, (for 230 volt operation) | 71400 | MDL 1/4 | | | | |
| 2110-0020 | Fuse, cartridge: 0.8 amp, s-b, (for 115 volt operation) | 75915 | 313-800 | 1 | 10 | | |
| 2140-0012 | Lamp, minat: 2 pin, No. 12 | 24455 | No. 12 | 5 | 5 | | |
| 3100-0290 | Switch, rot, 1 sect, 2 pos, w/R8 var resistor | 76854 | 218429-K1P | 1 | 1 | | |
| 3101-0001 | Switch, tog: SPST | 04009 | 80994-H | 1 | 1 | | |
| 3101-0033 | Switch, sl: DPDT | 42190 | 4633 | 1 | 1 | | |
| 3140-0013 | Motor: 6.3, VAC | 73061 | "Synchron" Model 610 (6.3V) | 1 | 1 | | |
| 8120-0050 | Cord, power: w/NEMA plug | 70903 | CS-0041/PH-151/7.5 ft | 1 | 1 | | |
| 9100-0021 | Transformer, power | 98734 | 4076 | 1 | 1 | | |
| | MISCELLANEOUS | | | | | | |
| G-74G | Knob, black: 1 in. ZERO CONTROL | | | | | | |
| G-74N | Knob, bar w/arrow RANGE (volts) SWITCH | | | | | | |
| G-74AT | Knob, red: 3/4 in. bar w/arrow NORMAL EXPAND SWITCH | | | | | | |
| 412A-37A | Light rod: modulator (cmo) | | | | | | |
| 412A-37B | Light rod: modulator (rmo) | | | | | | |
| 412A-65A | Assy, amplifier | | | | | | |
| 412A-65A-1 | Circuit board, amplifier: includes C108 thru C110, C112, C113, R106 thru R109, R111 thru R114, V101, V102 | | | | | | |

# See introduction to this section

# APPENDIX
# CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

**The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.**

| CODE NO. | MANUFACTURER | ADDRESS |
|---|---|---|
| 00334 | Humidial Co. | Colton, Calif. |
| 00335 | Westrex Corp. | New York, N.Y. |
| 00373 | Garlock Packing Co., Electronic Products Div. | Camden, N.J. |
| 00656 | Aerovox Corp. | New Bedford, Mass. |
| 00779 | Amp, Inc. | Harrisburg, Pa. |
| 00781 | Aircraft Radio Corp. | Boonton, N.J. |
| 00853 | Sangamo Electric Company, Ordill Division (Capacitors) | Marion, Ill. |
| 00866 | Goe Engineering Co. | Los Angeles, Calif. |
| 00891 | Carl E. Holmes Corp. | Los Angeles, Calif. |
| 01121 | Allen Bradley Co. | Milwaukee, Wis. |
| 01255 | Litton Industries, Inc. | Beverly Hills, Calif. |
| 01281 | Pacific Semiconductors, Inc. | Culver City, Calif. |
| 01295 | Texas Instruments, Inc. Transistor Products Div. | Dallas, Texas |
| 01349 | The Alliance Mfg. Co. | Alliance, Ohio |
| 01561 | Chassi-Trak Corp. | Indianapolis, Ind. |
| 01589 | Pacific Relays, Inc. | Van Nuys, Calif. |
| 01930 | Amerock Corp. | Rockford, Ill. |
| 01961 | Pulse Engineering Co. | Santa Clara, Calif. |
| 02114 | Ferroxcube Corp. of America | Saugerties, N.Y. |
| 02286 | Cole Mfg. Co. | Palo Alto, Calif. |
| 02660 | Amphenol-Borg Electronics Corp. | Chicago, Ill. |
| 02735 | Radio Corp. of America Semiconductor and Materials Div. | Somerville, N.J. |
| 02771 | Vocaline Co. of America, Inc. | Old Saybrook, Conn. |
| 02777 | Hopkins Engineering Co. | San Fernando, Calif. |
| 03508 | G.E. Semiconductor Products Dept. | Syracuse, N.Y. |
| 03705 | Apex Machine & Tool Co. | Dayton, Ohio |
| 03797 | Elcoma Corp. | El Monte, Calif. |
| 03877 | Transitron Electronic Corp. | Wakefield, Mass. |
| 03888 | Pyrofilm Resistor Co. | Morristown, N.J. |
| 03954 | Air Marine Motors, Inc. | Los Angeles, Calif. |
| 04009 | Arrow, Hart and Hegeman Elect. Co. | Hartford, Conn. |
| 04062 | Elmenco Products Co. | New York, N.Y. |
| 04222 | Hi-Q Division of Aerovox | Myrtle Beach, S.C. |
| 04298 | Elgin National Watch Co., Electronics Division | Burbank, Calif. |
| 04404 | Dymec Division of Hewlett-Packard Co. | Palo Alto, Calif. |
| 04651 | Sylvania Electric Prods., Inc. Electronic Tube Div. | Mountain View, Calif. |
| 04713 | Motorola, Inc., Semiconductor Prod. Div. | Phoenix, Arizona |
| 04732 | Filtron Co., Inc. Western Division | Culver City, Calif. |
| 04773 | Automatic Electric Co. | Northlake, Ill. |
| 04870 | [illegible] Motor Co. | Chicago, Ill. |
| 05006 | Twentieth Century Plastics, Inc. | Los Angeles, Calif. |
| 05277 | Westinghouse Electric Corp., Semi-Conductor Dept. | Youngwood, Pa. |
| 05593 | Illumitronic Engineering Co. | Sunnyvale, Calif. |
| 05624 | Barber Colman Co. | Rockford, Ill. |
| 05729 | Metropolitan Telecommunications Corp., Metro Cap. Div. | Brooklyn, N.Y. |
| 05783 | Stewart Engineering Co. | Santa Cruz, Calif. |
| 06004 | The Bassick Co. | Bridgeport, Conn. |
| 06555 | Beede Electrical Instrument Co., Inc. | Penacook, N.H. |
| 06812 | Torrington Mfg. Co., West Div. | Van Nuys, Calif. |
| 07115 | Corning Glass Works Electronic Components Dept. | Bradford, Pa. |
| 07126 | Digitran Co. | Pasadena, Calif. |
| 07137 | Transistor Electronics Corp. | Minneapolis, Minn. |
| 07138 | Westinghouse Electric Corp. Electronic Tube Div. | Elmira, N.Y. |
| 07261 | Avnet Corp. | Los Angeles, Calif. |
| 07263 | Fairchild Semiconductor Corp. | Mountain View, Calif. |
| 07910 | Continental Device Corp. | Hawthorne, Calif. |
| 07933 | Rheem Semiconductor Corp. | Mountain View, Calif. |
| 07980 | Boonton Radio Corp. | Boonton, N.J. |
| 08145 | U.S. Engineering Co. | Los Angeles, Calif. |
| 08358 | Burgess Battery Co. | Niagara Falls, Ontario, Canada |
| 08717 | Sloan Company | Burbank, Calif. |
| 08718 | Cannon Electric Co. Phoenix Div. | Phoenix, Ariz. |
| 08792 | CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc. | Lowell, Mass. |
| 09026 | Babcock Relays, Inc. | Costa Mesa, Calif. |
| 09134 | Texas Capacitor Co. | Houston, Texas |
| 09250 | Electro Assemblies, Inc. | Chicago, Ill. |
| 09569 | Mallory Battery Co. of Canada, Ltd. | Toronto, Ontario, Canada |
| 10411 | Tl-Tal, Inc. | Berkeley, Calif. |
| 10446 | Carborundum Co. | Niagara Falls, N.Y. |
| 11236 | CTS of Berne, Inc. | Berne, Ind. |
| 11237 | Chicago Telephone of California, Inc. | So. Pasadena, Calif. |
| 11312 | Microwave Electronics Corp. | Palo Alto, Calif. |
| 11711 | General Instrument Corporation Semiconductor Division | Newark, N.J. |
| 11717 | Imperial Electronics, Inc. | Buena Park, Calif. |
| 11870 | Melabs, Inc. | Palo Alto, Calif. |
| 12697 | Clarostat Mfg. Co. | Dover, N.H. |
| 14655 | Cornell Dubilier Elec. Corp. | So. Plainfield, N.J. |
| 15909 | The Daven Co. | Livingston, N.J. |
| 16758 | Delco Radio Div. of G. M. Corp. | Kokomo, Ind. |
| 18873 | E. I. DuPont and Co., Inc. | Wilmington, Del. |
| 19315 | Eclipse Pioneer, Div. of Bendix Aviation Corp. | Teterboro, N.J. |
| 19500 | Thomas A. Edison Industries, Div. of McGraw-Edison Co. | West Orange, N.J. |
| 19701 | Electra Manufacturing Co. | Kansas City, Mo. |
| 20183 | Electronic Tube Corp. | Philadelphia, Pa. |
| 21520 | Fansteel Metallurgical Corp. | No. Chicago, Ill. |
| 21335 | The Fafnir Bearing Co. | New Britain, Conn. |
| 21964 | Fed. Telephone and Radio Corp. | Clifton, N.J. |
| 24446 | General Electric Co. | Schenectady, N.Y. |
| 24455 | G.E., Lamp Division | Nela Park, Cleveland, Ohio |
| 24655 | General Radio Co. | West Concord, Mass. |
| 26462 | Grobet File Co. of America, Inc. | Carlstadt, N.J. |
| 26992 | Hamilton Watch Co. | Lancaster, Pa. |
| 28480 | Hewlett-Packard Co. | Palo Alto, Calif. |
| 33173 | G.E. Receiving Tube Dept. | Owensboro, Ky. |
| 35434 | Lectrohm Inc. | Chicago, Ill. |
| 37942 | P. R. Mallory & Co., Inc. | Indianapolis, Ind. |
| 39543 | Mechanical Industries Prod. Co. | Akron, Ohio |
| 40920 | Miniature Precision Bearings, Inc. | Keene, N.H. |
| 42190 | Muter Co. | Chicago, Ill. |
| 43990 | C. A. Norgren Co. | Englewood, Colo. |
| 44655 | Ohmite Mfg. Co. | Skokie, Ill. |
| 47904 | Polaroid Corp. | Cambridge, Mass. |
| 48620 | Precision Thermometer and Inst. Co. | Philadelphia, Pa. |
| 49956 | Raytheon Company | Lexington, Mass. |
| 54294 | Shallcross Mfg. Co. | Selma, N.C. |
| 55026 | Simpson Electric Co. | Chicago, Ill. |
| 55933 | Sonotone Corp. | Elmsford, N.Y. |
| 55938 | Sorensen & Co., Inc. | So. Norwalk, Conn. |
| 56137 | Spaulding Fibre Co., Inc. | Tonawanda, N.Y. |
| 56289 | Sprague Electric Co. | North Adams, Mass. |
| 59446 | Telex, Inc. | St. Paul, Minn. |
| 61775 | Union Switch and Signal, Div. of Westinghouse Air Brake Co. | Swissvale, Pa. |
| 62119 | Universal Electric Co. | Owosso, Mich. |
| 64959 | Western Electric Co., Inc. | New York, N.Y. |
| 65092 | Weston Inst. Div. of Daystrom, Inc. | Newark, N.J. |
| 66346 | Wollensak Optical Co. | Rochester, N.Y. |
| 70276 | Allen Mfg. Co. | Hartford, Conn. |
| 70309 | Aitiad Control Co., Inc. | New York, N.Y. |
| 70485 | Atlantic India Rubber Works, Inc. | Chicago, Ill. |
| 70563 | Amperite Co., Inc. | New York, N.Y. |
| 70903 | Belden Mfg. Co. | Chicago, Ill. |
| 70998 | Bird Electronic Corp. | Cleveland, Ohio |
| 71002 | Birnbach Radio Co. | New York, N.Y. |
| 71041 | Boston Gear Works Div. of Murray Co. of Texas | Quincy, Mass. |
| 71218 | Bud Radio Inc. | Cleveland, Ohio |
| 71284 | Camloc Fastener Corp. | Paramus, N.J. |
| 71311 | Allen D. Cardwell Electronic Prod. Corp. | Plainville, Conn. |
| 71400 | Bussmann Fuse Div. of McGraw-Edison Co. | St. Louis, Mo. |
| 71450 | CTS Corp. | Elkhart, Ind. |
| 71468 | Cannon Electric Co. | Los Angeles, Calif. |
| 71471 | Cinema Engineering Co. | Burbank, Calif. |
| 71482 | C. P. Clare & Co. | Chicago, Ill. |
| 71528 | Standard-Thomson Corp., Clifford Mfg. Co. Div. | Waltham, Mass. |
| 71590 | Centralab Div. of Globe Union Inc. | Milwaukee, Wis. |
| 71708 | The Cornish Wire Co. | New York, N.Y. |
| 71744 | Chicago Miniature Lamp Works | Chicago, Ill. |
| 71763 | A. O. Smith Corp., Crowley Div. | West Orange, N.J. |
| 71785 | Cinch Mfg. Corp. | Chicago, Ill. |
| 71984 | Dow Corning Corp. | Midland, Mich. |
| 72136 | Electro Motive Mfg. Co., Inc. | Willimantic, Conn. |
| 72354 | John E. Fast & Co. | Chicago, Ill. |
| 72619 | Dialight Corp. | Brooklyn, N.Y. |
| 72656 | General Ceramics Corp. | Keasbey, N.J. |
| 72758 | Girard-Hopkins | Oakland, Calif. |
| 72765 | Drake Mfg. Co. | Chicago, Ill. |
| 72825 | Hugh H. Eby Inc. | Philadelphia, Pa. |
| 72928 | Gudeman Co. | Chicago, Ill. |
| 72982 | Erie Resistor Corp. | Erie, Pa. |
| 73061 | Hansen Mfg. Co., Inc. | Princeton, Ind. |
| 73138 | Heilipot Div. of Beckman Instruments, Inc. | Fullerton, Calif. |
| 73293 | Hughes Products Division of Hughes Aircraft Co. | Newport Beach, Calif. |
| 73445 | Amperex Electronic Co., Div. of North American Phillips Co., Inc. | Hicksville, N.Y. |
| 73506 | Bradley Semiconductor Corp. | Hamden, Conn. |
| 73559 | Carling Electric, Inc. | Hartford, Conn. |
| 73682 | George K. Garrett Co., Inc. | Philadelphia, Pa. |
| 73743 | Fischer Special Mfg. Co. | Cincinnati, Ohio |
| 73793 | The General Industries Co. | Elyria, Ohio |
| 73905 | Jennings Radio Mfg. Co. | San Jose, Calif. |
| 74455 | J. H. Winns, and Sons | Winchester, Mass. |

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H4-1 Dated October 1961
H4-2 Dated November 1961

# APPENDIX
## CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

| CODE NO. | MANUFACTURER | ADDRESS |
|---|---|---|
| 74861 | Industrial Condenser Corp. | Chicago, Ill. |
| 74868 | R.F. Products Division of Amphenol-Borg Electronics Corp. | Danbury, Conn. |
| 74970 | E. F. Johnson Co. | Waseca, Minn. |
| 75042 | International Resistance Co. | Philadelphia, Pa. |
| 75173 | Jones, Howard B., Division of Cinch Mfg. Corp. | Chicago, Ill. |
| 75378 | James Knights Co. | Sandwich, Ill. |
| 75382 | Kulka Electric Corporation | Mt. Vernon, N.Y. |
| 75818 | Lenz Electric Mfg. Co. | Chicago, Ill. |
| 75915 | Littelfuse Inc. | Des Plaines, Ill. |
| 76005 | Lord Mfg. Co. | Erie, Pa. |
| 76210 | C. W. Marwedel | San Francisco, Calif. |
| 76433 | Micamold Electronic Mfg. Corp. | Brooklyn, N.Y. |
| 76487 | James Millen Mfg. Co., Inc. | Malden, Mass. |
| 76493 | J. W. Miller Co. | Los Angeles, Calif. |
| 76530 | Monadnock Mills | San Leandro, Calif. |
| 76545 | Mueller Electric Co. | Cleveland, Ohio |
| 76854 | Oak Manufacturing Co. | Chicago, Ill. |
| 77068 | Bendix Pacific Division of Bendix Corp. | No. Hollywood, Calif. |
| 77321 | Phaostron Instrument and Electronic Co. | South Pasadena, Calif. |
| 77342 | Potter and Brumfield, Div. of American Machine and Foundry | Princeton, Ind. |
| 77630 | Radio Condenser Co. | Camden, N.J. |
| 77638 | Radio Receptor Co., Inc. | Brooklyn, N.Y. |
| 77764 | Resistance Products Co. | Harrisburg, Pa. |
| 78283 | Signal Indicator Corp. | New York, N.Y. |
| 78471 | Tilley Mfg. Co. | San Francisco, Calif. |
| 78488 | Stackpole Carbon Co. | St. Marys, Pa. |
| 78553 | Tinnerman Products, Inc. | Cleveland, Ohio |
| 78790 | Transformar Engineers | Pasadena, Calif. |
| 78947 | Ucinite Co. | Newtonville, Mass. |
| 79142 | Veeder-Root, Inc. | Hartford, Conn. |
| 79251 | Wenco Mfg. Co. | Chicago, Ill. |
| 79727 | Continental-Wirt Electronics Corp. | Philadelphia, Pa. |
| 79963 | Zierick Mfg. Corp. | New Rochelle, N.Y. |
| 80031 | Mepco Division of Sessions Clock Co. | Morristown, N.J. |
| 80130 | Times Facsimile Corp. | New York, N.Y. |
| 80131 | Electronic Industries Association Any brand tube meeting EIA standards | Washington, D.C. |
| 80207 | Unimax Switch, Div. of W. L. Maxson Corp. | Wallingford, Conn. |
| 80248 | Oxford Electric Corp. | Chicago, Ill. |
| 80294 | Bourns Laboratories, Inc. | Riverside, Calif. |
| 80411 | Acro Div. of Robertshaw Fulton Controls Co. | Columbus 16, Ohio |
| 80486 | All Star Products Inc. | Dellance, Ohio |
| 80583 | Hammerland Co., Inc. | New York, N.Y. |
| 80640 | Stevens, Arnold, Co., Inc. | Boston, Mass. |
| 81030 | International Instruments, Inc. | New Haven, Conn. |
| 81415 | Wilkor Products, Inc. | Cleveland, Ohio |
| 81453 | Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations | Newton, Mass. |
| 81483 | International Rectifier Corp. | El Segundo, Calif. |
| 81860 | Barry Controls, Inc. | Watertown, Mass. |
| 82042 | Carter Parts Co. | Skokie, Ill. |
| 82142 | Jeffers Electronics Division of Speer Carbon Co. | Du Bois, Pa. |
| 82170 | Allen B. DuMont Labs., Inc. | Clifton, N.J. |
| 82209 | Maguire Industries, Inc. | Greenwich, Conn. |
| 82219 | Sylvania Electric Prod. Inc., Electronic Tube Div. | Emporium, Pa. |
| 82376 | Astron Co. | East Newark, N.J. |
| 82389 | Switchcraft, Inc. | Chicago, Ill. |
| 82647 | Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods. | Attleboro, Mass. |
| 82866 | Research Products Corp. | Madison, Wis. |
| 82877 | Rotron Manufacturing Co., Inc. | Woodstock, N.Y. |
| 82893 | Vector Electronic Co. | Glendale, Calif. |
| 83058 | Carr Fastener Co. | Cambridge, Mass. |
| 83125 | Pyramid Electric Co. | Darlington, S.C. |
| 83148 | Electro Cords Co. | Los Angeles, Calif. |
| 83186 | Victory Engineering Corp. | Union, N.J. |
| 83298 | Bendix Corp., Red Bank Div. | Red Bank, N.J. |
| 83330 | Smith, Herman H., Inc. | Brooklyn, N.Y. |
| 83501 | Gavitt Wire and Cable Co., Div. of Amerace Corp. | Brookfield, Mass. |
| 83594 | Burroughs Corp., Electronic Tube Div. | Plainfield, N.J. |
| 83777 | Model Eng. and Mfg., Inc. | Huntington, Ind. |
| 83821 | Loyd Scruggs Co. | Festus, Mo. |
| 84171 | Arco Electronics, Inc. | New York, N.Y. |
| 84396 | A. J. Glessner Co., Inc. | San Francisco, Calif. |
| 84411 | Good All Electric Mfg. Co. | Ogallala, Neb. |
| 84970 | Sarkes Tarzian, Inc. | Bloomington, Ind. |
| 85454 | Boonton Molding Company | Boonton, N.J. |
| 85474 | R. M. Bracamonte & Co. | San Francisco, Calif. |
| 85660 | Rolled Kards, Inc. | New Haven, Conn. |
| 85911 | Seamless Rubber Co. | Chicago, Ill. |
| 86684 | Radio Corp. of America, RCA Electron Tube Div. | Harrison, N.J. |
| 87216 | Philco Corp. (Lansdale Division) | Lansdale, Pa. |
| 87473 | Western Fibrous Glass Products Co. | San Francisco, Calif. |
| 88140 | Cutler-Hammer, Inc. | Lincoln, Ill. |
| 89473 | General Electric Distributing Corp. | Schenectady, N.Y. |
| 89636 | Carter Parts Div. of Economy Baler Co. | Chicago, Ill. |
| 89665 | United Transformer Co. | Chicago, Ill. |
| 90179 | U.S. Rubber Co., Mechanical Goods Div. | Passaic, N.J. |
| 90978 | Bearing Engineering Co. | San Francisco, Calif. |
| 91260 | Connor Spring Mfg. Co. | San Francisco, Calif. |
| 91418 | Radio Materials Co. | Chicago, Ill. |
| 91506 | Augat Brothers, Inc. | Attleboro, Mass. |
| 91637 | Dale Electronics, Inc. | Columbus, Nebr. |
| 91662 | Elco Corp. | Philadelphia, Pa. |
| 91737 | Gremar Mfg. Co., Inc. | Wakefield, Mass. |
| 91827 | K F Development Co. | Redwood City, Calif. |
| 91921 | Minneapolis-Honeywell Regulator Co., Micro-Switch Division | Freeport, Ill. |
| 92196 | Universal Metal Products, Inc. | Bassett Puente, Calif. |
| 93332 | Sylvania Electric Prod. Inc., Semiconductor Div. | Woburn, Mass. |
| 93369 | Robbins and Myers, Inc. | New York, N.Y. |
| 93410 | Stevens Mfg. Co., Inc. | Mansfield, Ohio |
| 93983 | Insuline-Van Norman Ind., Inc. Electronic Division | Manchester, N.H. |
| 94144 | Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation | Quincy, Mass. |
| 94145 | Raytheon Mfg. Co., Semiconductor Div. California Street Plant | Newton, Mass. |
| 94148 | Scientific Radio Products, Inc. | Loveland, Colo. |
| 94154 | Tung-Sol Electric, Inc. | Newark, N.J. |
| 94197 | Curtiss-Wright Corp., Electronics Div. | East Paterson, N.J. |
| 94318 | Tru Ohm Prod. Div. of Model Engineering and Mfg. Co. | Chicago, Ill. |
| 94682 | Worcester Pressed Aluminum Corp. | Worcester, Mass. |
| 95236 | Allies Products Corp. | Miami, Fla. |
| 95238 | Continental Connector Corp. | Woodside, N.Y. |
| 95263 | Leecraft Mfg. Co., Inc. | New York, N.Y. |
| 95264 | Lerco Electronics, Inc. | Burbank, Calif. |
| 95265 | National Coil Co. | Sheridan, Wyo. |
| 95275 | Vitramon, Inc. | Bridgeport, Conn. |
| 95354 | Methode Mfg. Co. | Chicago, Ill. |
| 95987 | Weckesser Co. | Chicago, Ill. |
| 96067 | Huggins Laboratories | Sunnyvale, Calif. |
| 96095 | Hi-O Division of Aerovox | Olean, N.Y. |
| 96256 | Thordarson-Meissner Div. of Maguire Industries, Inc. | Mt. Carmel, Ill. |
| 96296 | Solar Manufacturing Co. | Los Angeles, Calif. |
| 96330 | Carlton Screw Co. | Chicago, Ill. |
| 96341 | Microwave Associates, Inc. | Burlington, Mass. |
| 96501 | Excel Transformer Co. | Oakland, Calif. |
| 97539 | Automatic and Precision Mfg. Co. | Yonkers, N.Y. |
| 97966 | CBS Electronics, Div. of C.B.S., Inc. | Danvers, Mass. |
| 98141 | Axel Brothers Inc. | Jamaica, N.Y. |
| 98220 | Francis L. Mosley | Pasadena, Calif. |
| 98278 | Microdot, Inc. | So. Pasadena, Calif. |
| 98291 | Sealectro Corp. | Mamaroneck, N.Y. |
| 98405 | Carad Corp. | Redwood City, Calif. |
| 98734 | Palo Alto Engineering Co., Inc. | Palo Alto, Calif. |
| 98821 | North Hills Electric Co. | Mineola, N.Y. |
| 98925 | Clevite Transistor Prod. Div. of Clevite Corp. | Waltham, Mass. |
| 98978 | International Electronic Research Corp. | Burbank, Calif. |
| 99109 | Columbia Technical Corp. | New York, N.Y. |
| 99313 | Varian Associates | Palo Alto, Calif. |
| 99515 | Marshall Industries, Electron Products Division | Pasadena, Calif. |
| 99707 | Control Switch Division, Controls Co. of America | El Segundo, Calif. |
| 99800 | Delevan Electronics Corp. | East Aurora, N.Y. |
| 99848 | Wilco Corporation | Indianapolis, Ind. |
| 99934 | Raybrandt, Inc. | Boston, Mass. |
| 99942 | Hoffman Semiconductor Div. of Hoffman Electronics Corp. | Evanston, Ill. |
| 99957 | Technology Instrument Corp. of Calif. | Newbury Park, Calif. |

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

| | | |
|---|---|---|
| 0000F | Malco Tool and Die | Los Angeles, Calif. |
| 0000I | Teisfunken (c/o American Elitel | New York, N.Y. |
| 0000L | Winchester Electronics, Inc. | Santa Monica, Calif. |
| 0000M | Western Coil Div. of Automatic Ind., Inc. | Redwood City, Calif. |
| 0000N | Nahm-Bros. Spring Co. | San Leandro, Calif. |
| 0000P | Ty-Car Mfg. Co., Inc. | Holliston, Mass. |
| 0000T | Texas Instruments, Inc. Metals and Controls Div. | Versailles, Ky. |
| 0000U | Tower Mfg. Corp. | Providence, R.I. |
| 0000W | Webster Electronics Co. Inc. | New York, N.Y. |
| 0000X | Spruce Pine Mica Co. | Spruce Pine, N.C. |
| 0000Y | Midland Mfg. Co. Inc. | Kansas City, Kans. |
| 0000Z | Willow Leather Products Corp. | Newark, N.J. |
| 0000A | A British Radio Electronics Ltd. | Washington, D.C. |
| 0000B | Precision Instrument Components Co. | Van Nuys, Calif. |
| 0000C | Computer Diode Corp. | Lodi, N.J. |
| 0000D | General Transistor | Los Angeles, Calif. |
| 0000E | A. Williams Manufacturing Co. | San Jose, Calif. |
| 0000F | Carmichael Corrugated Specialties | Richmond, Calif. |
| 0000G | Goshen Die Cutting Service | Goshen, Ind. |

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# MANUAL CHANGES

MODEL 413A

DC NULL VOLTMETER

Manual Serial Prefixed: 139-
Manual Printed: 2/62

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

| Instrument Serial Prefix | Make Manual Changes | Instrument Serial Prefix | Make Manual Changes |
|---|---|---|---|
| 139- | ERRATA | | |
| 315- | 1, ERRATA | | |
| ALL | ERRATA | | |
| | | | |

ERRATA

Figure 5-16, Power Supply schematic diagram,
Center-arm of R8 (ZERO) should be connected to R125, 126 and S101H.

F1 (115V): Change to fuse, cartridge, 0.6 amp, slo-blo (for 115V operation), ℗ Stock No. 2110-0016

F1 (230V): Change to fuse, cartridge, 0.4 amp, slo-blo (for 230V operation), ℗ Stock No. 2110-0019

Paragraph 5-16, DEMODULATOR
j) should read, Replace DS103 and remove DS104

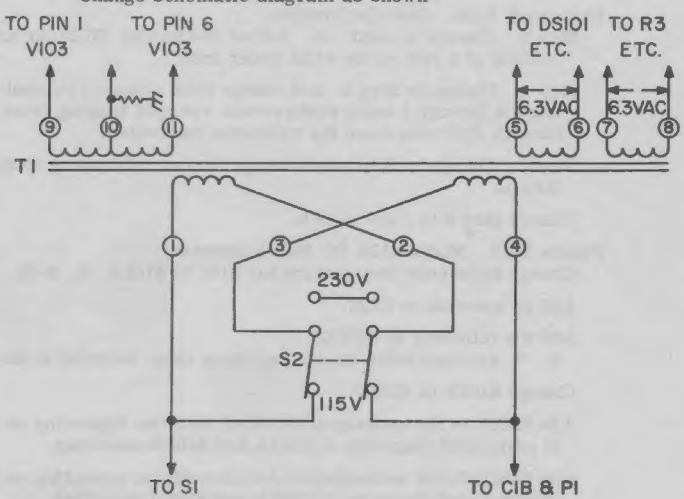
p) Turn the 413A off and replace DS104 and V102.

Paragraph 5-35, Step a
Change to, 413A or 412A

CHANGE #1

Table 6-1, Replaceable Parts
Change T1 to ℗ Stock No. 9100-0238

Figure 5-16. Power Supply
Change schematic diagram as shown




ERRATA

Table 1-1, SPECIFICATIONS.
Noise Specification should read, "Noise: Less than 2 mv (RMS) on any range."

| Instrument Serial Prefix | Make Manual Changes | Instrument Serial Prefix | Make Manual Changes |
|---|---|---|---|
| 139- | ERRATA | | |
| 315- | 1, ERRATA | | |
| ALL | ERRATA | | |
| | | | |

ERRATA

Figure 2-1. 230 Volt Operation,
Change S1 to S2.

Figure 4-1. Model 413A Block Diagram,
Add arrowhead to arc on A103 to indicate clockwise rotation of the light interrupter.

Paragraph 5-12. Chopper Assembly,
Step c. Delete last sentence.

Figure 5-1. A103, Chopper Assembly,
Change DS104-413AR to DS101-413AR.

Change DS103-413AR to DS102-413AR.

Change DS101-413AR to DS104-413AR.

Change DS102-413AR to DS103-413AR.

Paragraph 5-16. Demodulator,
Step d should read: Connect a 1 $\mu$f capacitor across the input terminals of an ohmmeter.

Paragraph 5-33. Hum Balance,
Step d. First sentence should read: Adjust Hum Bal. (R3) for minimum (less than 5 millivolts peak to peak) 10 cps signal as seen on oscilloscope.

Paragraph 5-35. Amplifier Gain Calibration and Meter Calibration,
Add the following sentence to Step f: Set voltmeter calibrator range switch to 1.0 volt.

Figure 5-8. Amplifier Calibration Test Setup,
Add (System Indicator) under ℌ 413A DC Null Voltmeter adjacent to the 413A under test.

Paragraph 5-38. Gain Calibration,
Step h. Change to read: m. Adjust Meter Cal. R123 for an end-scale reading of 1 volt on the 413A under test.

Step i. Change to Step h. and change first sentence to read: Repeat Steps c through f using positive test voltages ranging from 0.001 volt through 300 volts from the voltmeter calibrator.

Step j. Change to Step i and change the two references to Step i to read Step h.

Change Step k to j and m to k.

Figure 5-15. Model 413A DC Null Voltmeter,
Change Reference Designators for S101 to S101A, D, F-H.

Add an asterisk to R122.

Add the following to NOTES:
6. * Average value shown, optimum value selected at factory.

Change S101B to S101D.

Add S101A to the undesignated switch sections appearing on the left side of simplified diagrams of S101A and S101D switching.

Add S101D to the undesignated switch sections appearing on the right side of simplified diagrams of S101A and S101D switching.

Table 6-1. Reference Designation Index,
Change CR1 to ℌ Stock No. 1902-0206; Diode, breakdown; Mfr. 04713.

## WARRANTY

*All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.*

For assistance of any kind, including help with instruments under warranty, contact your authorized Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges.* Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

## CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

## SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

## GENERAL

Your authorized Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

**CUSTOMER SERVICE**

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: (415) 326-1755
TWX No. PAL AL 117-U
Cable: "HEWPACK"

**OR (In Western Europe)**

Hewlett-Packard S.A.
54-54bis Route Des Acacias
Geneva, Switzerland
Telephone: (022) 42. 81. 50
Cable: "HEWPACKSA"

413A-900

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